

San Francisco Estuary Regional Monitoring Program for Trace Substances

Contaminant Concentrations in Fish from San Francisco Bay, 2000

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Regional Monitoring Program
for Trace Substances**

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Abstract

In 2000, the Regional Monitoring Program (RMP) determined mercury, selenium, and trace organic contaminant concentrations in seven sport fish species from San Francisco Bay. This continues a long-term monitoring effort, begun in 1994, to determine how contaminated Bay fish are and how this contamination changes over time. As in previous sampling, fish samples exceeded human health screening values for most monitored contaminants. Screening values were exceeded for PCBs (90% of finfish samples), dioxin toxic equivalents (69%), mercury (38%), dieldrin (19%), selenium (17%; monitored in sturgeon only), and DDTs (4%). Many fish samples also contained detectable residues of the flame retardant compounds, PBDEs. Organic contaminant concentrations were significantly correlated to tissue lipid concentrations; fattier fish species, such as shiner surfperch and white croaker, had higher concentrations of PCBs, dioxins, DDTs, chlordanes, and PBDEs. Mercury concentrations were significantly correlated to fish size; larger fish species, such as striped bass and leopard shark, and larger individuals of each species, had higher tissue mercury concentrations. Statistically significant spatial variation was observed in concentrations of some contaminants, particularly for shiner surfperch and jacksmelt. Japanese littleneck clams and red rock crabs, sampled in 1998 and 1999, generally exhibited lower contaminant concentrations than finfish, although hepatopancreas samples from red rock crabs were relatively high in dioxins, PCBs, and DDTs.

This study documents changes in fish contamination over time at seasonal, interannual, and decadal time scales. In 2000, white croaker varied seasonally in trace organic contaminants and lipids, with significantly lower PCB and lipid concentrations in spring, compared to other seasons. For some fish species, concentrations of mercury, PCBs, DDTs and chlordanes fluctuated among 1994, 1997 and 2000. This interannual variation was sometimes related to changes in sampled fish size or fat content over the years. When RMP data for white sturgeon were compared to other data sources dating back to the 1980s, there was evidence of a recent decline for DDTs and chlordanes, but not for selenium. Striped bass showed no evidence of a trend in mercury concentrations between the early 1970s and the 1990s.

Abbreviations

ANOVA - analysis of variance

ANCOVA - analysis of covariance

BPTCP - Bay Protection and Toxic Cleanup Program

CDFG - California Department of Fish and Game

DDT - the sum of the following isomers and breakdown products: p,p'-DDT, o,p'-DDT, p,p'-DDE, o,p'-DDE, p,p'-DDD, and o,p'-DDD

NOAA - National Oceanic and Atmospheric Administration

OEHHA - Office of Environmental Health Hazard Assessment

PAH - polycyclic aromatic hydrocarbon

PBDE - polybrominated diphenyl ether

PCB - polychlorinated biphenyl

RMP - San Francisco Estuary Regional Monitoring Program

RSD - relative standard deviation

SFEI - San Francisco Estuary Institute

SFBRWQCB - San Francisco Bay Regional Water Quality Control Board (Regional Board)

SRM - standard reference materials

TEQ - dioxin toxic equivalent (see also Table 5)

TMDL - total maximum daily load report

TSMP - Toxic Substances Monitoring Program

U.S. EPA - Environmental Protection Agency

WHO - World Health Organization

Introduction

In 1994 the Bay Protection and Toxic Cleanup Program (BPTCP) performed a pilot study to measure concentrations of contaminants in fish in San Francisco Bay (SFRWQCB et al. 1995; Fairey et al. 1997). The study indicated that there were six chemicals or chemical groups that were of potential human health concern for people consuming Bay-caught fish: PCBs, mercury, DDT, dieldrin, chlordane, and dioxins. As a result of this pilot study the Office of Environmental Health Hazard Assessment (OEHHA) issued an interim health advisory for people consuming fish from San Francisco Bay (OEHHA 1997). This interim advisory is still in effect. The advisory states that:

1. Adults should limit consumption of Bay sport fish to, at most, two meals per month
2. Adults should not eat any striped bass over 35 inches (89 cm)
3. Pregnant women or women that may become pregnant or are breast-feeding, and children under 6 should not eat more than one meal per month, and should not eat any meals of shark over 24 inches (61 cm) or striped bass over 27 inches (69 cm)

The advisory does not apply to salmon, anchovies, herring, and smelt caught in the Bay, other ocean-caught sport fish, or commercial fish. The advice was issued due to concern over human exposure to residues of methylmercury, PCBs, dioxins, and organochlorine pesticides in Bay-caught fish.

In 1997, as a followup to the 1994 pilot study, the RMP began monitoring contaminants in Bay sport fish. The RMP fish contamination monitoring element includes a core monitoring program, conducted every three years, and special studies, which are designed to provide information that leads to improvements in the methods of or interpretation of data from the core program. This report documents findings from the second round of RMP sport fish sampling, conducted in 2000, and from small-scale special studies conducted in 1998, 1999, and 2000.

The objectives for the RMP fish contamination monitoring element are:

1. to produce the information needed for updating human health advisories and conducting human health risk assessments;
2. to measure contaminant levels in fish species over time to track temporal trends and to evaluate the effectiveness of management efforts;
3. to evaluate spatial patterns in contamination of sport fish and the Bay food web; and
4. to understand factors that influence contaminant accumulation in sport fish in order to better resolve signals of temporal and spatial trends.

In 2000, as in 1997, the core monitoring program targeted seven species that are frequently caught and eaten by Bay fishers at seven popular fishing areas in the Bay. The majority of the sampling and analytical effort was allocated toward characterizing

concentrations of contaminants of concern in these seven species in a manner that is as comparable as possible to the 1997 data.

The contaminants evaluated include mercury, PCBs, DDTs, chlordanes, PBDEs, dioxins, and selenium. This report presents results from these analyses. This includes characterizing contaminant concentrations in 2000, comparing them to human health screening values (Objective 1, above), and characterizing the spatial pattern in contamination among the RMP sampling sites (Objective 3). This report also evaluates long-term temporal trends (Objective 2) using the 1994, 1997, and 2000 data, in addition to data sets from other programs.

Several aspects of contaminant monitoring were expanded in 2000 as compared to previous years. In 1997, due to the relatively high expense of the chemical analysis, dioxins were analyzed in only 7 white croaker samples. Dioxin analysis was greatly expanded in 2000 thanks to the contribution of \$51,000 from U.S. EPA. In 2000, dioxins were analyzed in a total of 38 samples, with the additional analysis of several QA samples. Also in 2000, mercury analyses on individuals were conducted for large sport fish. For some fish species, mercury concentrations are highly dependent on the size of the fish. Analyzing individuals provided a basis for quantifying this relationship and a better foundation for long-term trend analysis. Polybrominated diphenyl ethers (PBDEs) were identified in fish sampled in 2000 and this report presents estimated concentrations of PBDEs in the fish.

This report carefully evaluates changes in fish contaminant concentrations over time. Changes are evaluated at seasonal, interannual, and long-term time scales. Some fish species are known to undergo seasonal physiological changes that affect organic contaminant concentrations in their tissues. In a 2000 special study, seasonal variation in organic contaminants was determined for white croaker. White croaker is the sport fish species that has exhibited the highest organic contaminant concentrations in San Francisco Bay studies. This report also characterizes changes in several fish species over three sampling years (1994, 1997, and 2000), now that comparable monitoring data are available. Finally, this report compares the RMP and BPTCP data set to high-quality data sets from other programs in order to obtain the most complete assessment possible of long-term trends in Bay fish contaminants.

This report also presents the results of special studies on contaminant concentrations in clams and crabs. In 1998, composite samples of clams were collected from two clamming locations (Oakland Harbor and South Bay). In 1999, composite samples of red rock crabs were collected from three locations (two on the San Francisco waterfront and one on the Sausalito waterfront). These special studies were undertaken to provide information on possible human exposure to contaminants from clam and crab consumption.

Related studies

Three important RMP fish studies are detailed in separate reports: a stable isotope study, a fish biomarker study, and a food web contaminant uptake model.

Analysis of stable isotopes was included in the core program in 2000, to provide information on food web transfer of contaminants to sport fish (Greenfield et al. In Review). Stable isotopes of nitrogen and carbon were analyzed in all of the fish samples. Resident bivalves were collected from several locations in the Bay and also analyzed to provide the baseline needed for interpretation of the fish isotope data. The stable isotope results help understand the potential implications of trophic position and fish movement patterns for contaminant concentrations in Bay fish.

Biomarkers are useful tools for determining contaminant effects to organisms. In a collaborative study, NOAA analyzed tissues from RMP white croaker samples for several biomarkers of contaminant effects on fish (Myers et al. 2002). NOAA has sampled white

croaker as an indicator of contaminant effects on fish in their National Status and Trends Program, including prior work in San Francisco Bay. The RMP and NOAA funded the analysis of biomarkers in the RMP samples jointly. Another component of this effort was the analysis of white croaker otoliths to determine the age of the fish. This biomarker evaluation was a precursor to the RMP Exposure and Effects Pilot Study (EEPS) that began in 2002 in order to meet the new RMP objective to evaluate contaminant effects in the Bay. Future work of this nature would be performed under the EEPS.

The third related study is a mathematical model of PCB movement from water and sediment through the food web and into three sport fish indicator species (white croaker, shiner surfperch, and jacksmelt) (Gobas and Wilcockson 2002). This work was funded by the RMP and performed by Dr. Frank Gobas of Simon Fraser University in Canada, a leader in this field. The San Francisco Bay Regional Water Quality Control Board funded extensive field work to provide input data needed for the model, including sampling of water, sediment, prey items, extra fish samples, and chemistry and taxonomy of gut contents of the RMP fish samples (Roberts et al. 2002). All of this work was aimed at developing a quantitative understanding of PCB accumulation in the RMP fish samples.

The RMP fish element reached a higher level of sophistication in 2000, with many new or expanded components. Through coordination with other agencies (U.S.EPA, NOAA, the Regional Board), significant additional information was extracted from these RMP samples in a cost effective manner. These different components were all aimed at meeting the objectives of the RMP relating to providing data for comparison to guidelines, characterizing temporal and spatial trends, and investigating the mechanisms and effects of contamination.

Methods

Field methods

The species and fishing locations in the Bay were selected for sampling based on available information on frequencies of catch and consumption by Bay fishers (Wade van Buskirk, Pacific States Marine Fisheries Commission, *personal communication*), continuity with the 1994 and 1997 sampling efforts, and to provide a broad geographic coverage of the Bay. The species sampled included jacksmelt (*Atherinopsis californiensis*), shiner surfperch (*Cymatogaster aggregata*), white croaker (*Genyonemus lineatus*), striped bass (*Morone saxatilis*), California halibut (*Paralichthys californicus*), leopard shark (*Triakis semifasciata*), and white sturgeon (*Acipenser transmontanus*). Information on the movements and food habits of these species is summarized in Davis et al. (1999b) and Greenfield et al. (In Review).

Study sampling locations are shown in Figure 1. To be consistent with the 1997 report (Davis et al. 1999b, 2002), the two South Bay Bridges locations (Redwood Creek and Coyote Creek) are combined for analysis as a single South Bay Bridges site. However, it should be noted that white croaker, shiner surfperch, and jacksmelt were predominantly caught adjacent to Redwood Creek and striped bass, leopard shark, and white sturgeon were predominantly caught adjacent to Coyote Creek (Figure 1). Shiner surfperch was the only species successfully captured at San Leandro Bay. In general, white croaker, shiner surfperch, and jacksmelt were successfully captured at all sites while other sport fish were collected at 2 - 3 sites (Table 1). Target size classes presented in Table 1 were based on legal limits, U.S. EPA (2000) guidance, and growth curves where available.

Fish were collected between May 1, 2000 and July 28, 2000. Additional sturgeon sampling was conducted on March 21-24 and April 21-24. To study the seasonal changes in contamination, additional white croaker were collected on March 7-8, (spring), September 26 (fall) and December 18-19 (winter). Collection gear included a 16 ft 1.25 in mesh size nylon stretch otter trawl, trammel nets (9 in and 4 in nylon mesh panels), gill

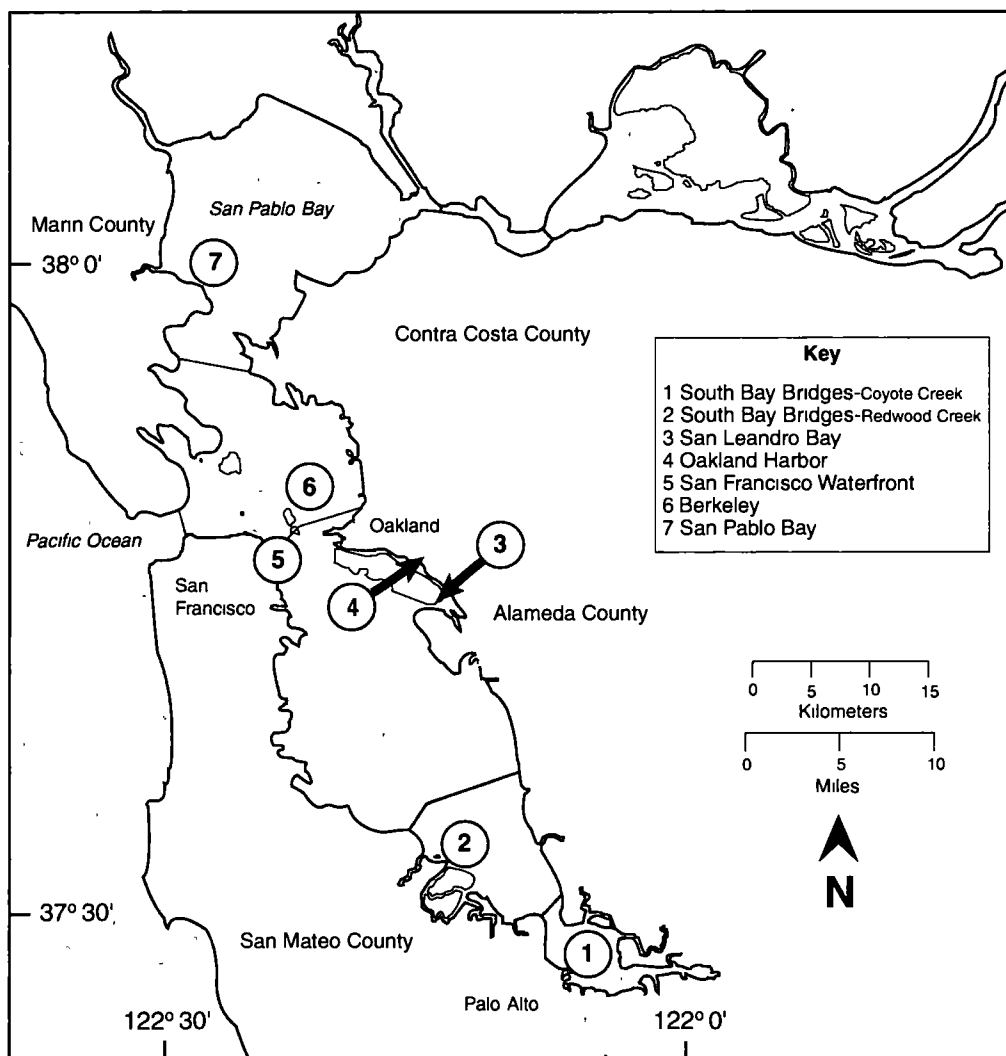


Figure 1. Sampling locations for 2000 RMP fish contamination monitoring. For the purposes of this report, results from the two South Bay Bridges locations are combined.

nets (0.75 in, 2.25 in, 2.5 in, and 4 in monofilament mesh), and hook and line. Otter trawls were used mostly for the collection of shiner surfperch, white croaker, and halibut. Trawls were run for 15-minute intervals. Gill nets were used most effectively to catch leopard sharks, striped bass, and sturgeon. Jacksmelt were caught exclusively with the 0.75 in gill net. In most cases, gill nets were set through a six-hour tidal cycle. Sampling was performed using an 18 ft Boston Whaler equipped with a hydraulic winch for deployment of deeper water otter trawls. A complete description of the field and laboratory sampling methods (MLML 2000) and a detailed cruise report are available from the San Francisco Estuary Institute (SFEI).

In order to determine contaminant concentrations in popular shellfish, crab and clam samples were collected and analyzed in addition to fish samples. The shellfish were collected at known areas of recreational clamming and crabbing. On April 8, 1998, two composite clam samples were collected, one from the South Bay at Burlingame, and the other from Oakland Harbor at Fruitvale Bridge (Figure 2). The sites were selected because local game wardens indicated that they were popular clamming locations (S. Foster and B. Arnold, CDFG, *personal communication*). Each composite contained 25 Japanese littleneck clams (*Tapes japonica*), ranging in shell length from 3.3 to 4.7 cm. These composites were analyzed for trace metals, PCBs, organochlorine pesticides, and PAHs. The entire body mass of soft tissue was analyzed. In addition to mercury and selenium, a

Table 1. Fish Contamination core monitoring program sampling design. Site boxes indicate actual number of analyses conducted for each contaminant group. OCs = PCBs, Pesticides, and PBDEs. Isotopes = stable carbon and nitrogen isotopes. Dioxins = dibenzodioxins, dibenzofurans, and coplanar PCBs. Se = selenium.

Species	White Croaker ^a	Shiner Surfperch	Jacksmelt	Leopard Shark	Striped Bass	California Halibut	White Sturgeon
Target # size classes	1	1	1	3	3	2	2
Target # fish/composite	5	20	5	3	3	3	3
Target size range (cm)	20–30	10–15	21–30	Small: 91-105 Medium: 106-140 Large: >140	Small: 45-59 Medium: 60-82 Large: >82		Small: 117-133 Large: 134-183
# Size classes caught	1	1	1	2 (small and medium)	2 (small and medium)	2	2
# Fish/composite	5	20	5	3	3	3	3
Size range (cm)	21-30	8-15	24-30	Small: 86-100 Medium: 98-134	Small: 45-58 Medium: 60-78	Small: 51-82 Large: 84-98	Small: 115-130 Large: 133-182
Tissue sampled	muscle with skin	muscle with skin	muscle with skin	muscle without skin	muscle without skin	muscle without skin	muscle without skin
South Bay Bridges	3 composites Hg+OCs+ Dioxins+ Isotopes X 3	3 composites Hg+OCs+ Isotopes X 3 Dioxins X 2	3 composites Hg+OCs+ Isotopes X 3	1 small 1 medium OCs X 2 Hg + Isotopes X 12 ^d	3 small OCs + Dioxins X 3 Hg + Isotopes X 9 ^d		1 small 1 medium Hg+OCs X 2 Isotopes + Se X 6
Oakland Harbor	3 composites ^b Hg+OCs+ Dioxins+ Isotopes X 3	3 composites Hg+OCs+ Isotopes X 3 Dioxins X 2	3 composites Hg+OCs+ Isotopes X 3 Dioxins X 1 ^c				
San Leandro Bay		3 composites Hg+OCs+ Isotopes X 3					
San Francisco Waterfront	3 composites Hg+OCs+ Dioxins+ Isotopes X 3	3 composites Hg+OCs+ Isotopes X 3 Dioxins X 2	3 composites Hg+OCs+ Isotopes X 3			1 small 1 medium OCs X 2 Hg + Isotopes X 6 ^d	
Berkeley	3 composites Hg+OCs+ Dioxins+ Isotopes X 3	3 composites Hg+OCs+ Isotopes X 3 Dioxins X 2	3 composites Hg+OCs+ Isotopes X 3	1 small 1 medium OCs X 2 Hg + Isotopes X 11 ^d	2 small 1 medium OCs + Dioxins X 3 Hg + Isotopes X 11 ^d		
San Pablo Bay	3 composites Hg+OCs+ Dioxins+ Isotopes X 3	3 composites Hg+OCs+ Isotopes X 3	3 composites Hg+OCs+ Isotopes X 3	1 small 1 medium OCs X 2 Hg + Isotopes X 9 ^d	3 small 1 medium OCs + Dioxins X 4 Hg + Isotopes X 12 ^d	1 small OCs X 1 Hg + Isotopes X 4 ^d	1 small 1 medium Hg+OCs X 2 Isotopes + Se X 6 ^d

a. 30 white croaker samples were analyzed for histopathology as presented in Myers et al. (2002)

b. Seasonal croaker study analyzed nine additional croaker composites at Oakland Harbor in spring, fall and winter

c. Composite of 15 fish

d. Individual fish analyzed

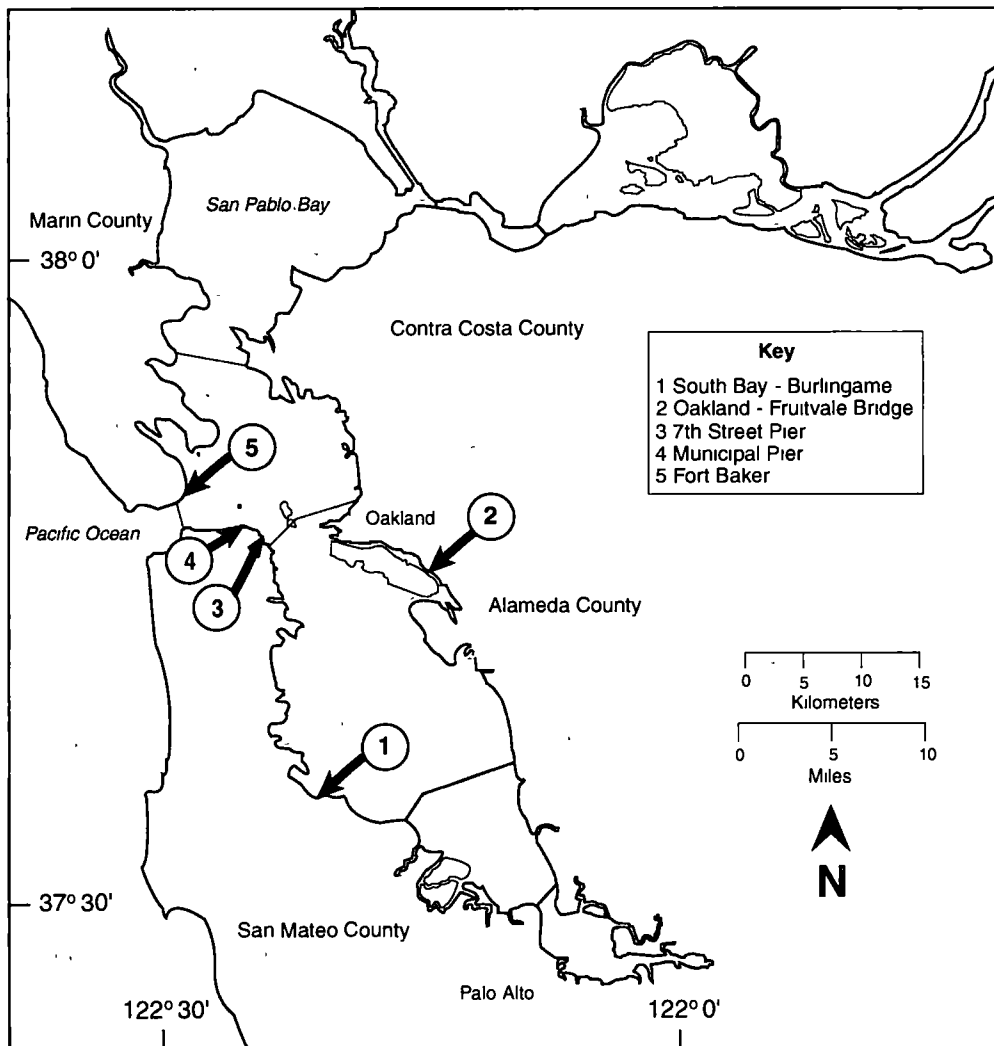


Figure 2. Crab and clam sampling locations for 2000 RMP contamination monitoring.

number of other trace metals were analyzed, and these data are reported in Appendix Table 2g.

Crab samples were collected September 28th through 30th, 1999, from 3 locations in the Central Bay: the Municipal Pier and 7th Street Pier on the San Francisco Waterfront, and Fort Baker on the Sausalito Waterfront (Figure 2). At each location, people were observed to be actively and successfully capturing crabs. Extensive efforts to collect crabs in the South Bay and San Pablo Bay were not successful. Twenty red rock crabs (*Cancer productus*), having carapace widths ranging from 10-15 cm, were collected from each site. Both muscle tissue and hepatopancreas tissue were subsampled from each crab and composited as follows. From each site, equal weight muscle subsamples were pooled into two batches of 10 crabs each, which were analyzed for trace metals, PCBs, and pesticides. This included analysis of total arsenic and total inorganic arsenic, performed by Frontier Geosciences Inc. A separate muscle subsample was taken from all 20 crabs from each site and composited for analysis of dioxins and coplanar PCBs. The hepatopancreas samples were composited from all 20 crabs, yielding one hepatopancreas composite per site, which was analyzed for trace metals, PCBs, and pesticides. Additional hepatopancreas tissue was composited from all three sites, resulting in one composite of 60 crab samples for analysis of dioxins and coplanar PCBs.

The results of all crab and clam analyses are presented in the corresponding fish tables in Appendix 2. Because this is the first time the RMP examines contamination in resident shellfish eaten by humans, the findings of the crab and clam study are presented in a separate section in this report.

Total length of each fish was measured in the field to the nearest cm. Surfperch and jacksmelt were wrapped in chemically cleaned Teflon sheeting and frozen whole on dry ice for transportation to the laboratory. Because of the large numbers and size of striped bass, leopard shark, and sturgeon, it was logistically unrealistic to keep them frozen whole. In order to bring an uncompromised sample back to the laboratory for homogenization, the following procedures were completed on these fish in the field. The intestinal tract was removed from the fish by opening the gut cavity slightly offset from the anus (to avoid opening any organs). An incision was made along the belly to the lower jaw. The entire digestive tract and gonads were removed and placed on a separate Teflon® cutting board to avoid contamination with the rest of the fish tissue. The head was removed just posterior to the operculum. White croaker were treated in a similar manner to the larger fish because histopathology samples of the digestive and reproductive organs required immediate processing, and were provided to NOAA/NMFS, Seattle WA (Myers et al. 2002). During dissection, the gonad tissue of the 12 croaker composites used in the seasonal study was weighed to determine the gonadal somatic index of each sample ($[\text{gonad tissue mass/body mass}] \times 100$). Otoliths of striped bass were archived for possible future analysis of age and movement patterns (e.g., Zlokovitz and Secor 1999).

Laboratory analysis

Muscle sample preparation was performed using non-contaminating techniques in a clean room environment. Fish samples were dissected and composited in a similar manner as in the previous RMP fish sampling (SFBRWQCB 1995; Davis et al. 1999b). Fillets of muscle tissue were removed in 5 to 10 g portions with Teflon forceps and stainless steel cutting utensils. Equal weight fillets were taken from each fish to composite a total of at least 175 g. Fish fillets were prepared in a fashion similar to the typical culinary preparation for each species. White croaker were prepared using muscle with skin. Shiner surfperch and jacksmelt were prepared for compositing by removing heads, tails, and guts, leaving muscle with skin and skeleton to be included in the composites. Leopard shark, striped bass, halibut, and sturgeon were prepared using muscle tissue without skin. All samples were homogenized using either a Büchi Mixer B400® or a Brinkman Polytron® mixer, both equipped with titanium blades. Sample splits were taken for each analysis after homogenization.

Samples were analyzed for mercury, selenium, PCBs, organochlorine pesticides, PBDEs, dibenzodioxins, dibenzofurans, and coplanar PCBs as indicated in Table 1. Analytical methods were described in SFBRWQCB et al. (1995). Briefly, aliquots analyzed for PCBs and organochlorine pesticides were extracted with methylene chloride:acetone (50:50) using pressurized fluid extraction (PFE) and extracts cleaned using gel permeation chromatography and fractionated using Florisil. Extracts were then analyzed by dual column (DB-5 and DB-17) gas chromatography with electron capture detection. Aliquots for mercury analysis were digested using nitric:sulfuric acid (70:30) and analyzed by a Flow Injection Mercury System. QA measures included analysis of standard reference materials, lab duplicates, and matrix spikes. All data met the data quality objectives specified in the RMP Quality Assurance Project Plan (QAPP) (Lowe et al., 1999). For mercury, SRM (DORM2 dogfish muscle) recoveries averaged 97.2%, and all were within the $\pm 25\%$ criterion established in the QAPP (Appendix Table 1a). For each individual PCB congener, 95% of the SRM 2974 and SRM 2978 (freeze dried mussel tissue) analyses were within acceptable range ($\pm 35\%$) of the certified concentrations (Appendix Table 1b). Similarly, for the organochlorine pesticides 86% of SRM 2974 and 75% of SRM 2978 analyses were within acceptable range ($\pm 35\%$) of the certified concen-

trations (Appendix Table 1c). Quality assurance reports prepared by the analytical laboratories are available from SFEI.

Screening values and statistical analysis

U.S. EPA (2000) defines screening values as concentrations of target analytes in fish or shellfish tissue that are of potential public health concern. Exceedance of screening values should be taken as an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted. With the exception of selenium, screening values were taken from Brodberg and Pollock (1999) and were calculated following U.S. EPA (2000) guidance. A consumption rate of 21 g fish/day was used in calculating screening values. This consumption rate is based on the median value of the distribution determined in a study of Santa Monica Bay (Allen et al. 1996). However, this rate is similar to a locally determined median of 16 g/day for consumers in San Francisco Bay (SFEI 2000). The screening values were changed somewhat from the 1994 and 1997 studies. The decision to use screening values taken from Brodberg and Pollock was based on the fact that these are the only locally derived screening values generated by the Office of Environmental Health Hazard Assessment (OEHHA), the organization that uses these data to produce and update fish consumption advisories. The screening value for selenium was reduced from 20 ppm to 2 ppm, also based on OEHHA recommendations (Robert Brodberg, OEHHA, *personal communication*). This 2 ppm screening value is based on human toxicity information, and accounts for the fact that humans consume additional selenium in other dietary items (Fan et al. 1988).

Statistical analyses were performed using SAS (SAS Institute, 1990). It is a standard and widely accepted statistical practice to transform data in the fashion that most successfully achieves distribution requirements of parametric analysis (e.g., Sokal and Rohlf 1995; Draper and Smith 1998). Therefore, based on examination of normal scores plots, contaminant concentration data were log or square root transformed to achieve normality prior to statistical analyses. When transformation did not achieve normality, nonparametric methods were used as described in individual contaminant sections.

One of the objectives of the RMP fish monitoring element is to track long-term trends in contaminant concentrations in the Bay food web. To that end, the sampling design has been similar in 1997 and 2000 to the 1994 BPTCP study. Data from three rounds of sampling, 1994, 1997, and 2000, can be readily compared to provide an indication of possible trends. Of the species sampled, four species had sufficient sample size to statistically compare the three sampling periods: leopard shark, striped bass, shiner surfperch, and white croaker. Additionally, RMP and BPTCP data were graphically compared to data from other programs (the Selenium Verification Study, CDFG, the Toxic Substances Monitoring Program and the CalFed Science Program), as described in individual contaminant sections. These comparisons were conducted to evaluate evidence for long-term temporal change.

Comparison of differences in wet-weight concentrations among locations (Figure 1) provides an indication of possible variation in human exposure to contaminants from consumption of fish from different locations in the Bay. Contaminant concentration comparisons among locations or among time periods were performed using standard ANOVAs for unbalanced design. Because of the large number of comparisons (23 species contaminant combinations for location comparisons; 16 species contaminant combinations for temporal comparisons) and the exploratory nature of the spatial analysis, it was desirable to be highly protected against Type I error with these comparisons. Therefore, significance of general spatial or temporal patterns was evaluated using Bonferroni protection ($\alpha = 0.05/[\text{total number of spatial or temporal comparisons made}]$). For contaminant-species combinations exhibiting significant patterns, Tukeys Studentized Range (HSD) Test was conducted to evaluate among-site differences. For mercury, evaluation of long-term patterns in striped bass was achieved using parametric analysis

of covariance (ANCOVA) to adjust the data for fish length. Prior to conducting ANCOVA, the subgroups were determined to have equal slopes using polynomial regression analysis with indicator variables (Tremblay et al. 1998).

Significant correlations between length and mercury accumulation and between lipid and trace organic accumulation were observed for some species. Spatial and temporal differences were evaluated using both the wet weight data and, where appropriate, data adjusted for length or lipid content. Additionally, graphical analysis techniques and evaluation of temporal change in length or lipid content were used to identify instances where these factors may affect temporal trends.

Mercury

Introduction

Mercury exposure is one of the primary concerns behind the interim advisory for the Bay. Mercury is a neurotoxicant, and is particularly hazardous for fetuses and children as their nervous systems develop. When children are exposed at high doses, mercury can cause serious problems, including mental impairment, impaired coordination, and other developmental abnormalities (U.S. EPA 1997). Similarly, in wildlife species high mercury exposure can cause damage to nervous, excretory, and reproductive systems, and early life stages are most sensitive (Wolfe et al. 1998).

Mercury exists in the environment in a variety of chemical forms. In terms of potential for biomagnification and impact to humans and wildlife, the most important form of mercury in the aquatic environment is methylmercury, which is readily accumulated by biota and transferred through the food web. Most of the mercury that accumulates in fish tissue is methylmercury (U.S. EPA 2000). Methylmercury is also the form of mercury of greatest toxicological concern at concentrations typically found in the environment. The Coast Range mountains north and south of the Bay contained the nation's most productive mercury mining districts. Historic mercury and gold mining activities have resulted in contamination of the Bay and its watershed (Nriagu 1994; Alpers and Hunerlach 2000; Domagalski 2001). Other sources of mercury include fossil fuel combustion, trace impurities in products such as bleach, and direct use of the metal in applications such as thermometers and dental amalgam (Davis et al. 1999a). Currently, mercury enters San Francisco Bay via erosion of bed sediments, loading from surrounding watersheds, stormwater runoff, and wastewater discharges (Johnson and Looker 2003). Mercury is a high priority contaminant on the 303(d) list of contaminants that impair water quality in the Estuary because water and fish collected from San Francisco Bay are at concentrations that may pose risks to humans and wildlife (SFBRWQCB 2001; Johnson and Looker 2003). Fish, especially long-lived predatory species, accumulate high concentrations of mercury and are fundamental indicators of the human and wildlife health risks associated with mercury in aquatic ecosystems.

Analytical considerations

The screening value for mercury, 0.3 µg/g wet weight, applies to methylmercury. Because of the higher cost of methylmercury analysis and data indicating that most mercury in fish tissue is present as methylmercury, U.S. EPA (2000) recommends that total mercury be measured in fish contaminant monitoring programs and the conservative assumption made that all mercury is present as methylmercury in order to be most protective of human health. Total mercury was measured in these samples.

The mercury concentrations in Bay fish were generally measurable with the analytical methods employed. Of the 134 samples measured, all but three were above the detection limit (0.0251 µg/g dry weight; Appendix Table 1a). In 2000, individual fish rather than composites were analyzed for mercury for those species exhibiting the

highest concentrations in 1994 and 1997 (leopard shark, striped bass, California halibut, and white sturgeon) (Fairey et al. 1997; Davis et al. 2002). This was done to obtain high-quality information on individual variation in mercury concentrations and to collect further data on the relationship between length and mercury concentrations.

Mercury data were log transformed to achieve normal distribution for the spatial ANOVA and square root transformed to achieve normal distribution for the temporal ANOVA and stepwise regression. Length data were not transformed.

In addition to RMP and BPTCP data, there are a number of data sets on striped bass mercury contamination in the Bay. These data extend from 1970 to the present. From 1970 to 1972, data were analyzed by California Department of Fish and Game's Water Pollution Control Laboratory (Kahn et al. 1971) using the same basic methodologies as the present analyses (sulfuric acid digestion followed by cold vapor atomic absorption spectroscopy). Although standard reference materials were not available at that time, quality assurance measures included duplicates, matrix spikes, reagent blanks, and intercalibration exercises with other laboratories (Dave Crane, CDFG, *personal communication*). For 18 sets of duplicate fish samples analyzed for mercury at the Water Pollution Control Lab between 1970 and 1972, the relative percent deviation was 9%, indicating reasonably high precision. This included six duplicate analyses of striped bass used in our results, which had an RPD of 8%. In 1999, striped bass were also analyzed from Suisun Bay as part of the CalFed Bay-Delta Mercury Project (Greenfield et al. 2001). Although these data have not been formally released yet, they were collected and analyzed by the same laboratory as for the RMP and BPTCP studies (California Department of Fish and Game, Moss Landing CA), and therefore have identical methods and quality assurance criteria. These multiple data sets are statistically compared to evaluate interannual variation in mercury concentrations, while accounting for potential length effects on slope and intercept. To achieve this, backwards elimination stepwise regression was performed with indicator variables (dummy variables) for each year's potential effect on both slope and intercept (Tremblay et al. 1998).

Data distribution and summary statistics

Mercury concentrations were highest in leopard shark, with a median concentration of 0.83 $\mu\text{g/g}$ wet weight (Table 2, Figure 3). White sturgeon and striped bass had intermediate concentrations, with median concentrations of 0.29 and 0.28 $\mu\text{g/g}$ wet, respectively. The lowest concentrations were measured in jacksmelt (median of 0.06 $\mu\text{g/g}$ wet) and shiner surfperch (0.08 $\mu\text{g/g}$ wet).

Mercury was measured in a total of 134 samples, and 51 (38%) had concentrations higher than the screening value of 0.30 $\mu\text{g/g}$ wet (Table 3). The only species with median mercury concentrations above the screening value was leopard shark (Table 2, Figure 3). All collected samples of leopard shark and 10 of 32 striped bass samples exceeded the mercury screening value. None of the jacksmelt or shiner surfperch samples exceeded the screening value.

Controlling factors

Within a given species, the older, and therefore larger, fish tend to accumulate higher mercury concentrations. In this study, length was used as an index of age. Significant correlations of mercury with length were observed for five of the seven species analyzed ($p < 0.05$; Figure 4). The only species not exhibiting a significant correlation between length and mercury were jacksmelt and shiner surfperch. Interestingly, the strength of the relationship between length and mercury concentration was related to the average size of a fish species. For larger fish, the R^2 of the length versus mercury relationship was greater (Figure 5). The strongest relationships were observed for leopard shark ($R^2 = 0.64$; $p < 0.0001$) and white sturgeon ($R^2 = 0.47$; $p = 0.013$), but a highly significant relationship was also observed for striped bass ($R^2 = 0.42$; $p < 0.0001$).

Table 2. Summary statistics by species for mercury and organochlorines. Data are medians. All PBDE values are estimates.

	Number of Composites Analyzed (Hg-Org-ITEQ)	Number in Composite	Length (cm)	Mercury (g/g wet)	Lipid %	Sum of Aroclors (ng/g wet)	Sum of PCB Congeners (ng/g wet)	Sum of DDTs (ng/g wet)	Sum of Chlordanes (ng/g wet)	Dieldrin (ng/g wet)	Sum of PBDEs (ng/g wet)	Dioxin Equivalents (TEQ-WHO) (pg/g wet)
Screening Value				0.30		20		100	30	2		0.3
California Halibut	10-3-0	1	70	0.21	0.4	24	22	6.0	ND	ND	3.0	NA
Jacksmelt	15-15-1	5	27	0.06	1.4	39	34	21	1.2	ND	4.3	0.2
Leopard Shark	32-6-0	3*	98	0.83	0.4	20	13	5.1	ND	ND	1.6	NA
Shiner Surfperch	18-18-8	20	11	0.08	2.6	207	135	37	8.1	ND	15	1.4
Striped Bass	32-10-10	3*	52	0.28	1.1	48	36	23	1.2	ND	6.5	0.2
White Croaker	15-24-15	3	27	0.21	4.0**	278**	191**	61**	9.4**	ND**	27**	1.6
White Sturgeon	12-4-0	5	132	0.29	0.7	52	43	13	1.3	ND	3.2	NA
Clam	2-2-0	25	3-5	0.08	0.9	NA	13	2.1	ND	ND	NA	NA
Crab (Muscle)	6-6-3	10	12	0.14	0.2	NA	4.9	ND	ND	ND	NA	0.1
Crab (Hepatopancreas)	3-3-1	20	12	0.05	4.3	NA	109	64	3.8	ND	NA	11

*Many of the striped bass and leopard shark Hg analyses were of individual fish

**Values include only summer croaker data. When all seasonal data are used, medians are as follows: % lipid = 4.3, Aroclors = 276, congeners = 191, DDTs = 62, chlordanes = 9.3, Dieldrin = 1.0, and PBDEs = 27.

ND = not detected. NA = not analyzed.

The reduced importance of length for smaller species could derive from a variety of biological mechanisms, as described in Davis et al. (2002). For example, mercury concentration strongly correlates with fish age and larger fish species may exhibit stronger size to age correlations. Additionally, because the smaller fish species tend to exhibit smaller home range sizes (Minns 1995; Greenfield et al. In Review), individual mercury concentration may vary more due to small-scale spatial heterogeneity in concentration of available mercury. One potential mechanism is that larger species may exhibit stronger correlations between trophic position and size. This was not supported by stable isotope analysis of the fish from the study. Surprisingly, isotope results suggested that the relationship between trophic position and mercury concentration was weak for most species (Greenfield et al. In Review). If this is the case, variation in trophic position may not be a particularly important controlling factor of mercury contamination among Bay sport fish. Additional analyses, including larger sample sizes at a specific location, and possibly gut content analyses of multiple species, would help confirm whether trophic position correlates with mercury accumulation in Bay fish.

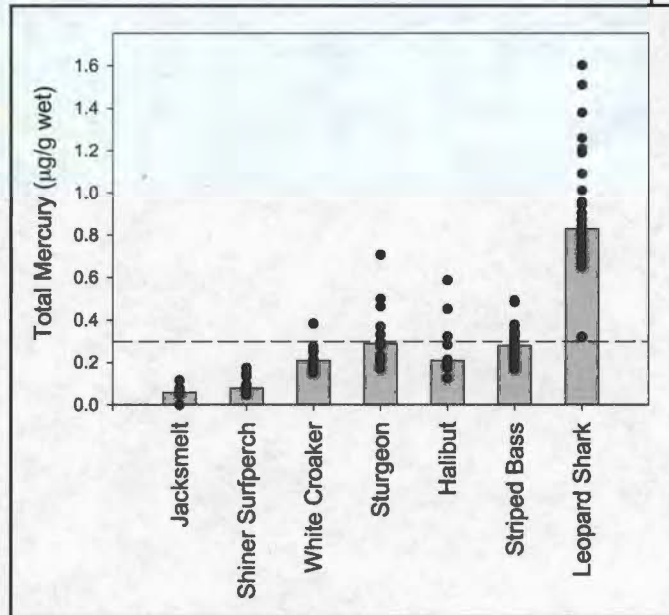


Figure 3. Mercury concentrations ($\mu\text{g/g}$ wet) in Bay fish, 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Horizontal line indicates screening value ($0.30 \mu\text{g/g}$ wet).

Spatial patterns

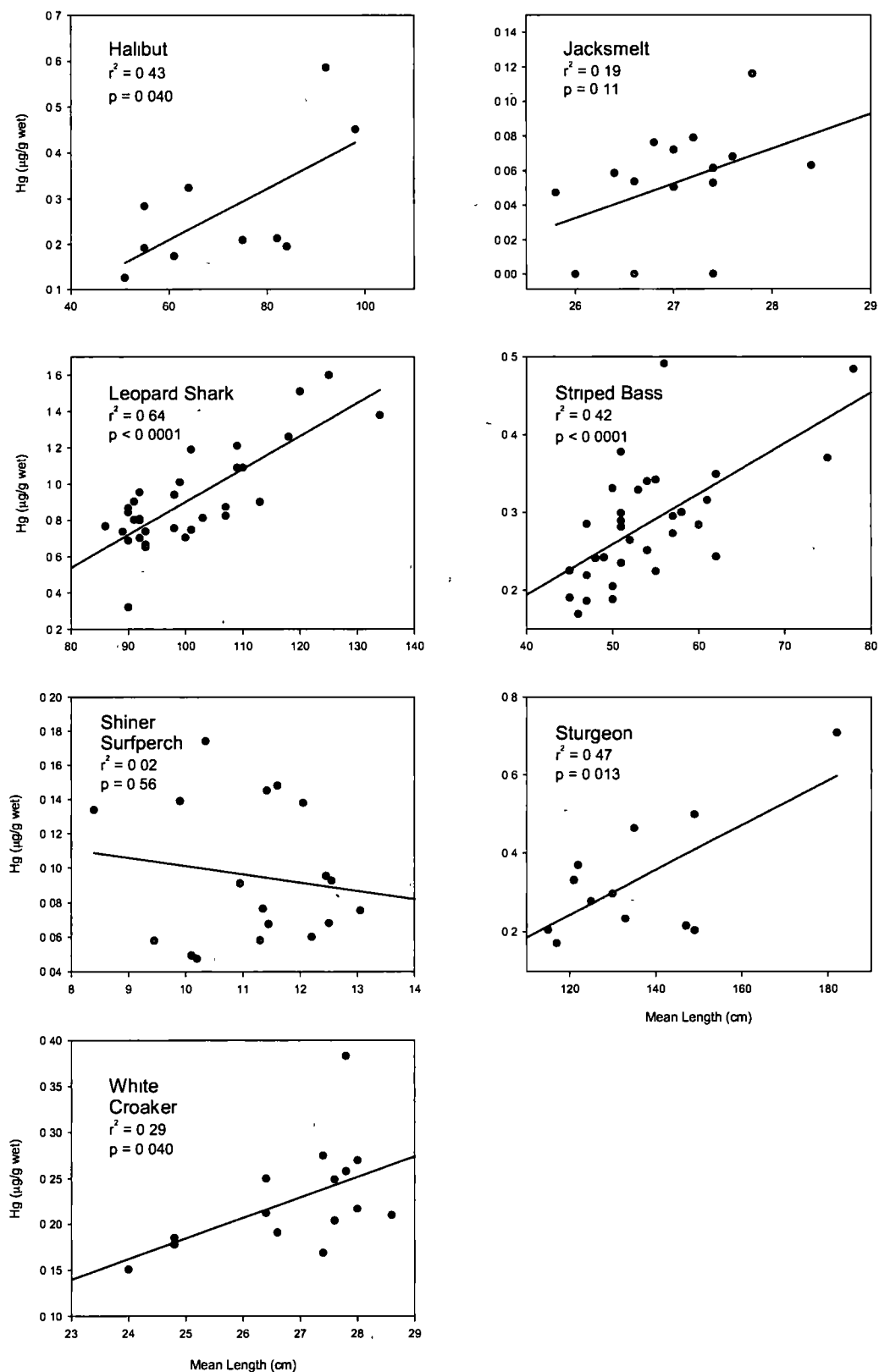
In order to have confidence that apparent differences among locations accurately reflect conditions in the Bay, it is necessary to have consistent results from replicate

Table 3. Summary of concentrations above screening values for each species. Numerator indicates the number above the screening value, denominator indicates the number of samples analyzed. Screening values from Brodberg and Pollack (1999).

	Mercury ($\mu\text{g/g}$ wet)	Sum of Aroclors (ng/g wet)	Sum of DDTs (ng/g wet)	Sum of Chlordanes (ng/g wet)	Dieldrin (ng/g wet)	Dioxin Equivalents (TEQ-WHO) (pg/g wet)
Screening value	0.30	20	100	30	2	0.3
Halibut	3/10	2/3	0/3	0/3	0/3	NA
Jacksmelt	0/15	12/15	0/15	0/15	0/15	0/1
Leopard Shark	32/32	3/6	0/6	0/6	0/6	NA
Shiner Surfperch	0/18	18/18	0/18	0/18	3/18	8/8
Striped Bass	10/32	10/10	0/10	0/10	0/10	0/9
White Croaker	1/15	24/24*	3/24*	0/24*	12/24*	14/14
Sturgeon	5/12	3/4	0/4	0/4	0/4	NA
Clam	0/2	NA	0/2	0/2	0/2	NA
Crab (Muscle)	0/6	NA	0/6	0/6	0/6	0/3
Crab (Hepatopancreas)	0/3	NA	0/3	0/3	0/3	1/1
All Finfish Species	51/134	72/80	3/80	0/80	15/80	22/32

*Includes analyses from seasonal croaker study

Figure 4. Regressions of mercury concentrations and average fish length in samples for each species. Data from 2000. Note differences in scale.



samples. In 2000, replicate sampling for mercury analysis, with at least three samples consisting of fish of uniform size, was performed at multiple locations for all species.

Statistically significant spatial variation in mercury concentrations was apparent for jacksmelt, leopard shark, shiner surfperch, and white sturgeon (Table 4). With the exception of shiner surfperch, all of these species exhibited relatively high mercury concentrations at the South Bay Bridges site (Figure 6; Table 4). Three species exhibited relatively low concentrations at the Berkeley site (Figure 6; Table 4).

In contrast to 1997, mercury concentrations at the Oakland Inner Harbor site were not significantly higher than most other sites for most species. One exception to this was shiner surfperch, which exhibited relatively high concentrations at Oakland Harbor. For white croaker, concentrations at Oakland Harbor were in fact lower than all other sites. This may partially result from the fact that the fish captured at Oakland Harbor were smaller than those captured at other sites, having a median length of 25 cm, as compared to 27 cm for all croaker. Additionally, Oakland Harbor croaker exhibited relatively low nitrogen isotope signatures, which may indicate lower trophic position (Greenfield et al. In Review).

Among the largest sport fish sampled, both leopard shark and white sturgeon exhibited significantly higher mercury concentrations in South Bay than San Pablo Bay.

The striped bass did not exhibit a significant spatial pattern, despite the fact that a relatively large number of samples were analyzed ($N = 32$). This may result from the extensive migratory behavior of this species (Calhoun 1952), but may also be due to among site variation in striped bass diet or life history.

The spatial patterns in fish mercury contamination that do occur may result from spatial variation in the amount of bioavailable mercury among sites. The South Bay Bridges site was elevated in mercury for several fish species (jacksmelt, leopard shark, and white sturgeon); this site is the closest fish study site to the Guadalupe River, which flows out from the New Almaden mercury mining district. Compared to most sources of mercury loading to the Bay, mercury concentrations in sediment from the Guadalupe River are relatively high (Johnson and Looker 2003). Additionally, the Guadalupe River exhibits elevated water and sediment mercury concentrations as compared to sites in the South, Central and San Pablo Bays (Leatherbarrow et al. 2002). The shiner surfperch exhibited significantly elevated mercury concentrations in San Leandro Bay and Oakland Harbor. These locations had elevated sediment mercury concentrations in an SFEI study (Daum et al. 2000) and an unpublished sediment mercury survey funded by the SFRWQCB (Wes Heim and Mark Stephenson, CDFG, *unpublished data*). The alternative hypothesis that among site variation in trophic position causes variation in fish mercury, is not well supported by stable isotope data (Greenfield et al. In Review).

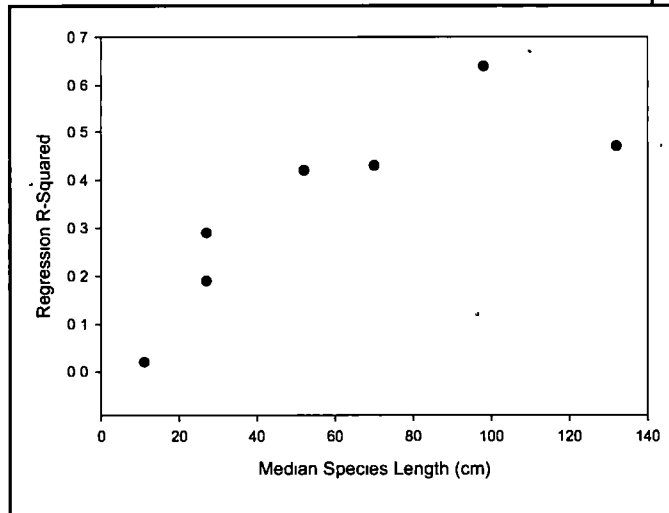


Figure 5. Strength of length versus mercury relationship (regression R^2) as a function of median species length. Each dot represents one of the seven fish species monitored in 2000.

Table 4. Contaminant concentrations (wet weight) at each sampling location for 2000. For each listing, mean values are presented. For multiple site comparisons for a given contaminant, sites with higher letters (e.g. B,C) are significantly higher than lower letter sites. Listings with no letter either do not exhibit significant differences (Bonferroni corrected ANOVA; Turkey-Kramer Multiple Comparison Procedure; $p < 0.05$) or do not have sufficient sample size to evaluate statistically. PCBs are presented as sum of congeners.

Congeners.		Species						
	Site	Jacksmelt	Shiner Surfperch	White Croaker	Striped Bass	Leopard Shark	Halibut	Sturgeon
Mercury ($\mu\text{g/g}$)	South Bay Bridges	0.077 B	0.093 B	0.284	0.242	1.117 B	-	0.444 B
	Oakland	0.063 B	0.144 C	0.166	-	-	-	-
	San Leandro Bay	-	0.149 C	-	-	-	-	-
	S.F. Waterfront	0.053 B	0.067 A	0.193	-	-	0.342	-
	Berkeley	0.000 A	0.068 A	0.258	0.339	0.847 A	-	-
	San Pablo Bay	0.073 B	0.051 A	0.232	0.267	0.714 A	0.175	0.218 A
PCBs (ng/g)	South Bay Bridges	62 B	164 C	202	40	32	-	43
	Oakland	65 B	241 D	235	-	-	-	-
	San Leandro Bay	-	288 D	-	-	-	-	-
	S.F. Waterfront	26 AB	120 BC	154	-	-	23	-
	Berkeley	12 A	96 B	140	63	12	-	-
	San Pablo Bay	32 B	60 A	214	31	7	22	37
DDTs (ng/g)	South Bay Bridges	24.8	38.8	59.1	21.3	10.7	-	12.5
	Oakland	17.1	41.8	65.7	-	-	-	-
	San Leandro Bay	-	43.1	-	-	-	-	-
	S.F. Waterfront	26.3	30.8	47.1	-	-	6.3	-
	Berkeley	22.2	41.9	42.5	28.9	3.0	-	-
	San Pablo Bay	22.4	24.2	94.5	21.1	3.7	6.0	19.8
Chlordanes (ng/g)	South Bay Bridges	4.0	12.7	13.0	0.9	0.6	-	1.3
	Oakland	1.7	13.8	10.8	-	-	-	-
	San Leandro Bay	-	24.5	-	-	-	-	-
	S.F. Waterfront	0.5	2.0	5.9	-	-	0.0	-
	Berkeley	0.0	3.0	5.0	2.9	0.0	-	-
	San Pablo Bay	0.8	4.0	12.4	0.8	0.0	0.0	0.9
PBDEs (ng/g)	South Bay Bridges	6.8	22.5 C	27.1	6.0	4.6	-	3.1
	Oakland	4.8	16.1 BC	37.2	-	-	-	-
	San Leandro Bay	-	13.1 B	-	-	-	-	-
	S.F. Waterfront	4.4	17.3 BC	24.1	-	-	3.0	-
	Berkeley	2.7	15.3 BC	18.9	12.1	1.7	-	-
	San Pablo Bay	4.3	5.9 A	31.2	6.4	1.1	3.0	5.0

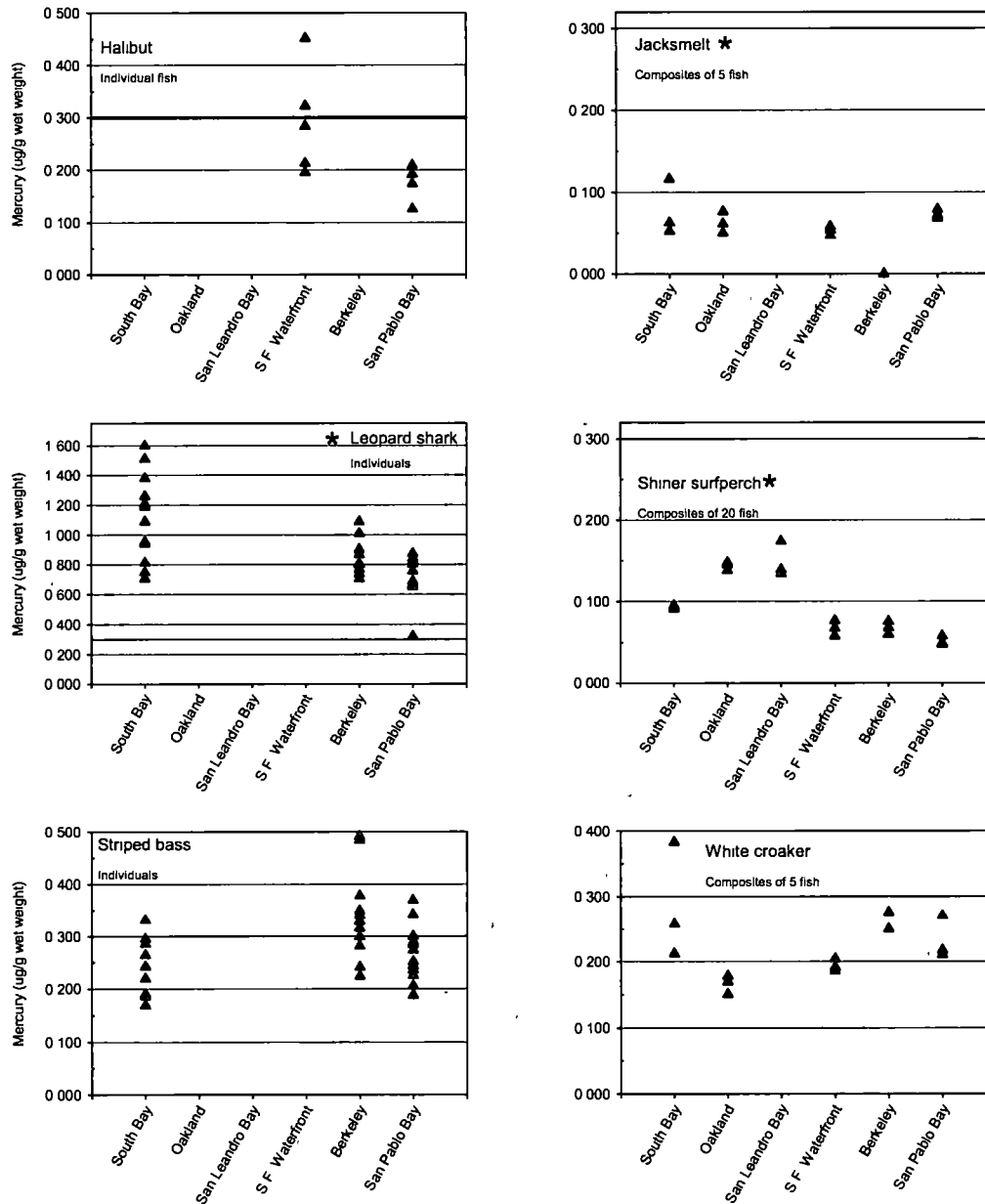


Figure 6. Mercury concentrations (µg/g wet) at each sampling location in 2000. White sturgeon data not shown. Line on plots indicate screening value of 0.30 µg/g wet. Points at zero indicate results below detection limits. Asterisk (*) indicates significance of analysis of variance at $p < 0.05$ (Bonferroni corrected). Note differences in scale.

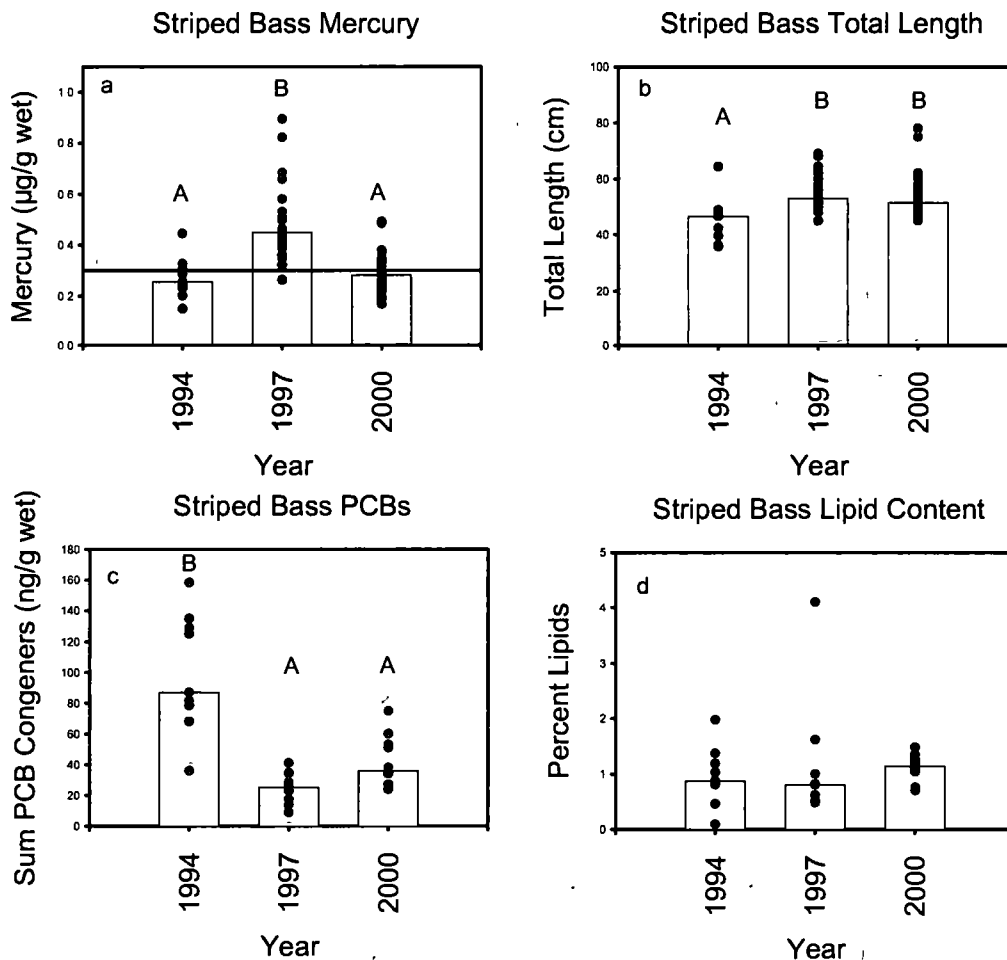
Temporal trends

Of the four species with multiple samples in 1994, 1997, and 2000, only striped bass exhibited statistically significant variation in mercury over those years ($R^2 = 0.47$; $p < 0.0001$). Leopard shark ($R^2 = 0.02$; $p = 0.70$), shiner surfperch ($R^2 = 0.10$; $p = 0.09$), and white croaker ($R^2 = 0.06$; $p = 0.21$) did not exhibit significant patterns. Mercury concentrations in striped bass were significantly higher in 1997 than they were in 1994 and 2000 (Figure 7a).

When long-term patterns in striped bass mercury concentrations were evaluated comparing data from the early 1970s and the 1990s, there was no clear upward or downward trend (Figure 8). Backwards elimination stepwise regression including all seven years indicated a statistically significant relationship between length and mercury for all years ($p < 0.0001$) and a significant increase in mercury concentration for 1997 ($p = 0.0009$) as compared to all other years. There was no significant difference among years in

Figure 7.

Change in selected striped bass attributes over consecutive RMP sampling periods. Points are concentrations in each sample analyzed. Bars indicate median concentrations. Capital letters indicate statistically significant difference among years by analysis of variance ($p < 0.05$; Bonferroni corrected for multiple comparisons). a) Tissue mercury concentration (line on plot indicates screening value of $0.3 \mu\text{g/g wet}$). b) Total length (cm). c) Tissue total PCB concentration (congener basis; ng/g). d) Tissue lipid content (%).



the slope of the length versus mercury relationship. Thus, when length effects were accounted for, 1997 was significantly higher in striped bass mercury concentrations than other years sampled.

There are several possible explanations for why striped bass mercury concentrations were higher in 1997 than the other years sampled. Possible explanations include variation in diet or that the bass from different years resided in different locations varying in food web mercury. Striped bass do show evidence of increased tissue Hg with increased trophic position (Greenfield et al. In Review), making it possible that temporal variation in diet causes variable uptake of mercury. However, the increase in 1997 is not simply a result of differences in fish length. The multiple year regression analysis showed elevated concentrations in 1997 even after accounting for length effects. Additionally, length was not significantly different between 1997 and 2000 despite the decrease in 2000 mercury concentrations (Figure 7a, 7b).

Another alternative explanation is that the amount of bioavailable mercury in the Estuary varied among years. In January of 1997, there was a flood event with elevated streamflow. This flood event flushed a large input of bioavailable methylmercury into the Bay, evidenced by huge increases in water methylmercury concentrations at Sacramento River monitoring sites (Domagalski 1998, 2001). Further evidence for this mercury loading event is the observation that total mercury concentrations in the RMP Sacramento and San Joaquin River sampling stations were higher in February of 1997 than all other RMP sampling years (Leatherbarrow and Lowe 2001). The fact that concentrations were not elevated in other Estuary fish species does not support the hypothesis that

striped bass mercury concentrations increased in 1997 due to this loading event. Nevertheless, striped bass exhibit considerable upstream migration (Calhoun 1952), which may expose them to elevated mercury in the Delta more than other fish species.

Mercury concentrations in striped bass do not appear to have consistently increased or decreased since the early 1970s. This lack of temporal pattern may be related to the presence of historic mercury sources in the region. Between 1850 and 1900, large amounts of mercury were extracted from mines in the Bay watershed. Much of this mercury was used to amalgamate gold in hydraulic mining processes in the Sierra

Nevada (Nriagu 1994; Alpers and Hunerlach 2000). As these wide-spread and poorly regulated mining operations are a significant source of mercury to the watershed (Nriagu 1994; Domagalski 2001), it may take decades or even centuries before the source inputs are successfully curtailed. Furthermore, the active sediment layer within the Estuary and erosion of buried sediments in the northern Estuary may provide continuous sources of total mercury to the overlying water column (Jaffe et al. 1998; Fuller et al. 1999).

Polychlorinated Biphenyls (PCBs)

Introduction

The term "polychlorinated biphenyl" refers to a group of 209 individual chemicals ("congeners") based on substitution of the biphenyl molecule with varying numbers of chlorine atoms. Due to their resistance to electrical, thermal, and chemical processes, PCBs were used in a wide variety of applications (e.g., in electrical transformers and capacitors, vacuum pumps, hydraulic fluids, lubricants, inks, and as a plasticizer) from the time of their initial commercial production in 1929 (Brinkmann and de Kok 1980). In the U.S. PCBs were sold as mixtures of congeners known as "Aroclors" with varying degrees of chlorine content. By the 1970s a growing appreciation of the toxicity of PCBs led to restrictions on their production and use. In 1979, a final PCB ban was implemented by the U.S. Environmental Protection Agency, prohibiting the manufacture, processing, commercial distribution, and use of PCBs except in totally enclosed applications (Rice and O'Keefe 1995). A significant amount of the world inventory of PCBs may still be in place in industrial equipment (Rice and O'Keefe 1995). Leakage from or improper handling of such equipment has led to PCB contamination of runoff from industrial areas. Other sources of PCBs to the Estuary are atmospheric deposition, effluents, and remobilization from sediment (Davis et al. 1999a).

Although their use has been restricted for almost two decades, PCBs remain among the environmental contaminants of greatest concern because many of the PCB congeners are potent toxicants that are resistant to degradation and have a strong tendency to accumulate in biota. As for mercury, PCBs are listed as a high priority contaminants on the 303(d) list of contaminants that impair water quality in the San Francisco Estuary (SFRWQCB 2001). Mass balance modeling indicates that the current mass of PCBs in the

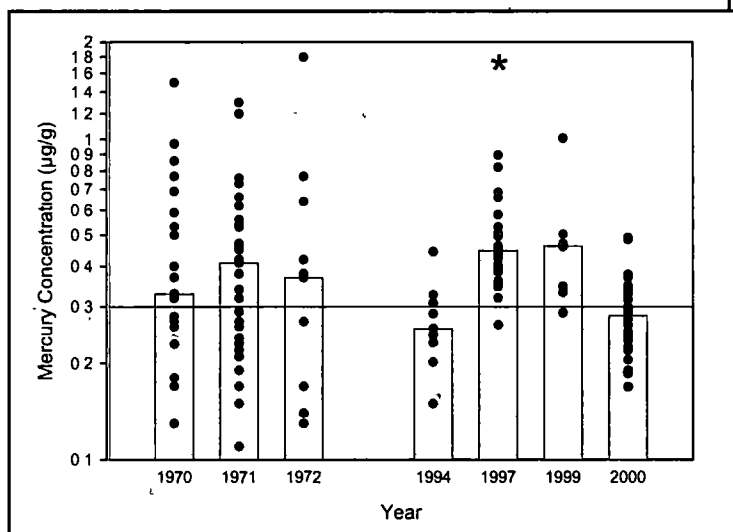


Figure 8.

Mercury concentrations in striped bass in the 1970s and 1990s. Gray bars indicate annual median concentrations. Horizontal line indicates screening value (0.30 µg/g wet). Asterisk above 1997 indicates significant difference from overall length versus mercury regression (see text). Data were obtained from CDFG historical records (1970-1972), a CalFed-funded collaborative study (1999), and the Regional Monitoring Program (1994, 1997 and 2000). Note log scale on y-axis.

Bay will take decades to be removed by natural processes (Davis 2002). In general, PCBs are not very toxic in acute exposures, but certain congeners are extremely toxic in chronic exposures. The most toxic PCB congeners are those that closely mimic the potency and mechanism of toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin ("dioxin", one of the most toxic compounds known). These PCB congeners can cause toxic symptoms similar to those caused by dioxin exposure, including developmental abnormalities and growth suppression, disruption of the endocrine system, impairment of immune function, and cancer promotion (Ahlborg et al. 1994; Van den Berg et al. 1998). The PCBs that most closely mimic the potency of dioxin are three congeners, PCB 77, PCB 126, and PCB 169. PCB 126 is the most potent congener by far, one-tenth as potent as dioxin, and is the congener of greatest concern in aquatic environments (Van den Berg et al. 1998). Other toxicologically active PCB congeners and their metabolites exert toxicities through different mechanisms than the dioxin-like congeners (McFarland and Clarke 1989). USEPA classifies PCBs as a probable human carcinogen (U.S. EPA 2000).

The toxicity of PCBs has historically been evaluated for Aroclor mixtures. In recent years toxicological data have begun to accumulate for specific PCB congeners, but overall the toxicological database is more complete for Aroclor mixtures than for PCB congeners (U.S. EPA 2000). U.S. EPA (2000) consequently recommends using an Aroclor screening value to evaluate fish tissue contamination. In this monitoring, as in the RMP in general, PCBs were measured on a congener-specific basis. Advantages of congener-specific data are described in Davis et al. (1997) and U.S. EPA (2000). The congener-specific results were used to estimate Aroclor concentrations using the method of Newman et al. (1998).

Due to their general resistance to metabolism and high affinity for lipids, PCBs and other similar organochlorines reach higher concentrations with increasing trophic level in aquatic environments; this process is known as "biomagnification" (Gobas et al. 1993; Suedel et al. 1994). The most toxic PCB congeners are also relatively resistant to metabolism (Davis 1997). Consequently, predatory fish, birds, and mammals (including humans that consume fish) at the top of the food web are particularly vulnerable to the effects of PCB contamination.

Analytical considerations

Two different methods were employed to measure PCBs. 48 PCB congeners were measured by the California Department of Fish and Game, Water Pollution Control Laboratory. This list included the congeners that are most abundant in environmental samples, but not PCBs 77, 126, and 169. A more elaborate and expensive technique is required to measure concentrations of PCBs 77, 126, and 169. Analyses of these three congeners were performed along with dioxin analyses by the Hazardous Materials Laboratory, Cal-EPA on a subset of samples. Results for these congeners are presented and discussed in the section on dioxins.

PCBs were measured on a congener-specific basis. Advantages of congener-specific PCB analysis are discussed in Davis et al. (1997). However, screening values for PCBs are expressed as Aroclors. The method of Newman et al. (1998) was employed to convert the congener data to Aroclor data. This method is based on comparing ratios of 14 congeners in samples with their ratios in the commercial mixtures Aroclor 1248, 1254, and 1260. The concentrations of Aroclors 1248, 1254, and 1260 were estimated in this manner and summed to obtain the "sum of Aroclors" for each sample. Unless otherwise indicated, PCB data presented in this report are expressed as the sum of Aroclors.

While some PCB congeners could be quantified in each sample, the low concentrations of congeners in 2.5 % of samples (2 of 80) translated to "not detected (ND)" concentrations of sum of Aroclors. These ND values were excluded from regression analyses of sum of Aroclors and lipid. The detection limit for each congener was 0.20 ng/g wet. MDLs expressed on an Aroclor basis (calculated from the congener data) were 10 ng/g wet for Aroclor 1254 and 1260 and 25 ng/g wet for Aroclor 1248.

To achieve normal distributions for the spatial ANOVA and the seasonal ANOVA, total PCB congener data were log transformed. When all three years of data were evaluated for the temporal ANOVA, square root transformation achieved the best approximation of a normal distribution.

Prior to the Regional Monitoring Program and Bay Protection and Toxic Cleanup Program, few data were collected on PCB concentrations in fish in San Francisco Bay. We compare the RMP and BPTCP findings to other data found for identical species in the Bay. All these comparisons are based on PCB concentrations measured using the Aroclor method. Risebrough (1969) determined PCBs in three composite samples of shiner surfperch, collected from the Central Bay in 1965, containing 10 to 15 individuals per sample. The Cooperative Striped Bass Study analyzed striped bass for PCBs in 1979, but only three fish were analyzed and all had observable health problems, indicating a nonrepresentative sample (CSWRCB 1980). Finally, the Toxic Substances Monitoring Program (TSMP) sampled sturgeon (1986-1992) and striped bass (1986-1988) from Suisun Bay. In each year, the TSMP analyzed a single composite of four to six fillets for each species. Quality assurance measures for the TSMP were comparable to RMP and included reagent blanks, 10 percent sample duplicates, and standard reference materials. Lab results were within 95 percent confidence intervals of reference parameters and duplicate precision was adequate (Rasmussen and Blethrow 1991; Rasmussen 1993, 1995). However, reporting limits were relatively high (50 ng/g for each Aroclor, as compared to 10 or 25 ng/g for RMP data).

Data distribution and summary statistics

Sum of Aroclor concentrations were highest in white croaker, with a median concentration of 278 ng/g wet, and shiner surfperch, with a median of 207 ng/g wet (Table 2, Figure 9). Sum of Aroclor concentrations were substantially lower in the other species sampled. The lowest median concentrations were measured in California halibut (24 ng/g) and leopard shark (20 ng/g).

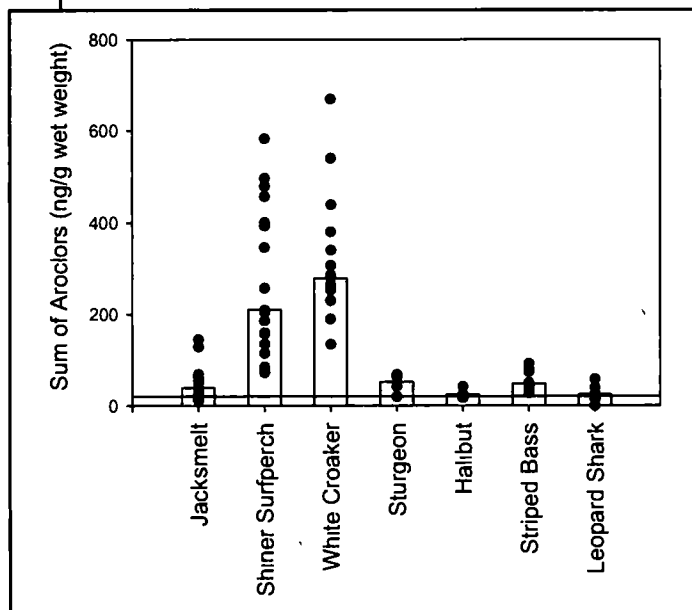
Sum of Aroclors was measured in a total of 80 samples; 72 samples had concentrations higher than the screening value of 20 ng/g wet (Table 3). Every species exhibited some exceedances. All of the white croaker, shiner surfperch, and striped bass samples exceeded the screening value. Most of the jacksmelt (12 of 15 samples), sturgeon (3 of 4), and halibut (2 of 3) samples exceeded the screening value.

Controlling factors

Sum of PCB congeners concentrations in the seven species sampled were significantly correlated ($R^2=0.49$; $p < 0.0001$) with lipid content (Figure 10a). The fish species with the highest lipid content in their muscle tissue had the highest PCB concentrations. However, close examination of Figure 10a reveals that for most species monitored, within-species variation in PCB concentrations is not positively correlated to lipid concentration. This absence of within-species positive correlation between PCBs and lipid content has been observed for nonspawning fish by Stow et al. (1997). Stow et al. hypothesized that the lack of correlation among nonspawning individuals might derive from differences in lipid type influencing contaminant affinity. Another possibility is that within a given species, fatter fish are healthier, therefore exhibiting greater growth rates and growth dilution (e.g., Brown and Murphy 1991). Finally, the limited range of lipid variation within the individual species might not be wide enough for a statistically significant relationship with contamination.

One exception to the lack of correlation within species was white croaker. When the seasonally sampled Oakland Harbor sites were included, white croaker exhibited a strong positive correlation between PCBs and lipid content. This correlation may derive from the fact that the seasonal sampling captured variability due to loss in PCB body burden with spawning events, which is further discussed in **Temporal Trends**, below.

Figure 9. PCB concentrations in Bay fish, expressed as sum of Aroclors (ng/g wet), 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Horizontal line indicates screening value (20 ng/g wet).



Previously we hypothesized that species and individuals feeding higher in the food web would have higher concentrations of PCBs and other trace organic contaminants. Surprisingly, stable isotope analyses of jacksmelt, shiner surfperch, and white croaker, did not support this hypothesis. The absence of correlation between nitrogen isotope signature and tissue PCB concentrations indicates that trophic position doesn't necessarily influence PCB concentrations for Bay area fish (Greenfield et al. In Review).

Spatial patterns

Statistically significant spatial patterns were observed for both shiner surfperch and jacksmelt. The jacksmelt exhibited greater than fourfold variation and shiner surfperch exhibited greater than tenfold variation in mean PCB concentrations among sampled sites (Figure 11, Table 4). Jacksmelt exhibited significantly lower concentrations at Berkeley than at South Bay Bridges, Oakland Harbor, or San Pablo Bay. Shiner surfperch exhibited significantly lower concentrations at San Pablo Bay than all other sites and significantly higher concentrations at Oakland and San Leandro Bay than the remaining sites. Additionally, for shiner surfperch, South Bay Bridges concentrations were significantly higher than concentrations at Berkeley or San Pablo Bay (Table 4).

Among the four species with sufficient sample size to conduct spatial ANOVAs (shiner surfperch, jacksmelt, white croaker, and striped bass), spatial pattern was most important in predicting PCB concentrations for the smallest fish species, shiner surfperch ($R^2 = 0.96$). For the larger species, white croaker and striped bass, sampling location was not as predictive of PCB concentrations ($R^2 = 0.61$ and 0.75 , respectively). This increase in the importance of sampling location for smaller fish species was also observed in 1997. Potential mechanisms behind this pattern are discussed in previous reports (Davis et al. 1999b; Davis et al. 2002). Stable isotope evidence supports the contention that the smaller shiner surfperch is more sedentary than croaker or striped bass (Greenfield et al. In Review).

Temporal trends

White croaker were collected seasonally from the Oakland Inner Harbor site in 2000 to test for seasonal variation in organochlorine contaminant concentrations. Three composites of croaker were analyzed for PCBs and other trace organic contaminants from each of four sampling periods (March, June, September, and December). For PCBs, considerable variation in sample concentration was explained by sampling period (ANOVA $R^2 = 0.69$; $p = 0.019$), indicating that the croaker tissue PCB concentrations exhibit seasonal variation. Concentrations were significantly lower ($p < 0.05$) in spring (mean = 115 ng/g), as compared to summer (mean = 277 ng/g) and fall (mean = 314 ng/g) (Figure 12b).

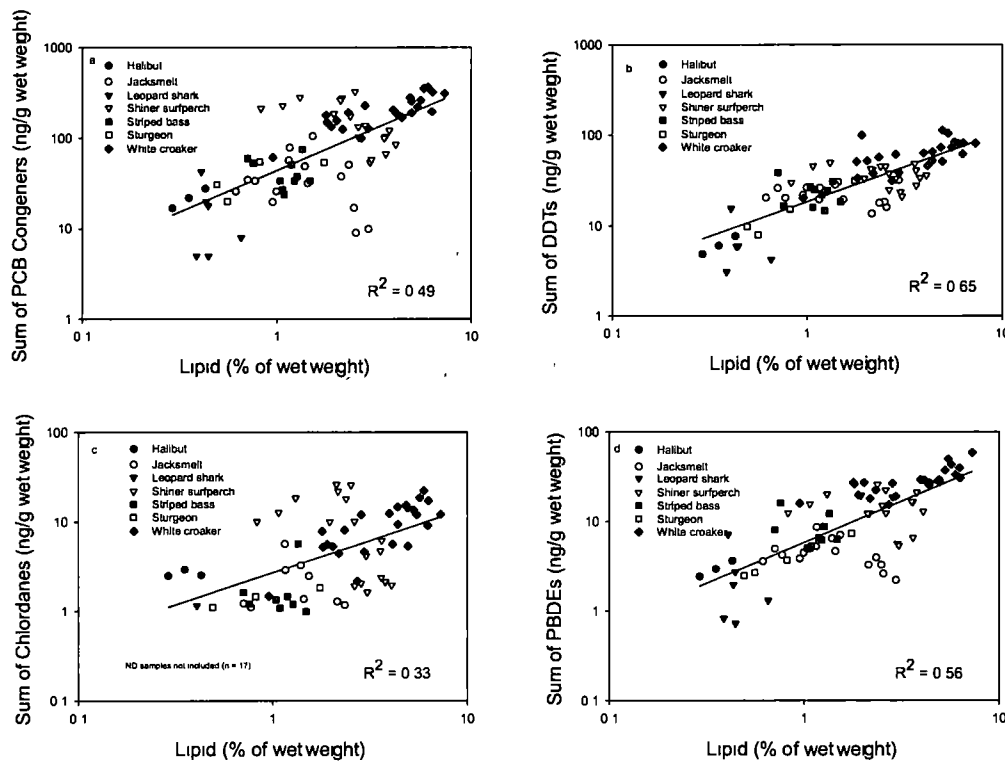


Figure 10. Regressions of concentrations of trace organic contaminants in all species (ng/g) versus percent lipid in composite samples. a) PCBs (as sum of congeners). b) DDTs. c) Chlordanes. d) PBDEs. Data are taken from 2000, include seasonal sampling of white croaker, but do not include samples below detection limit. Note log scale.

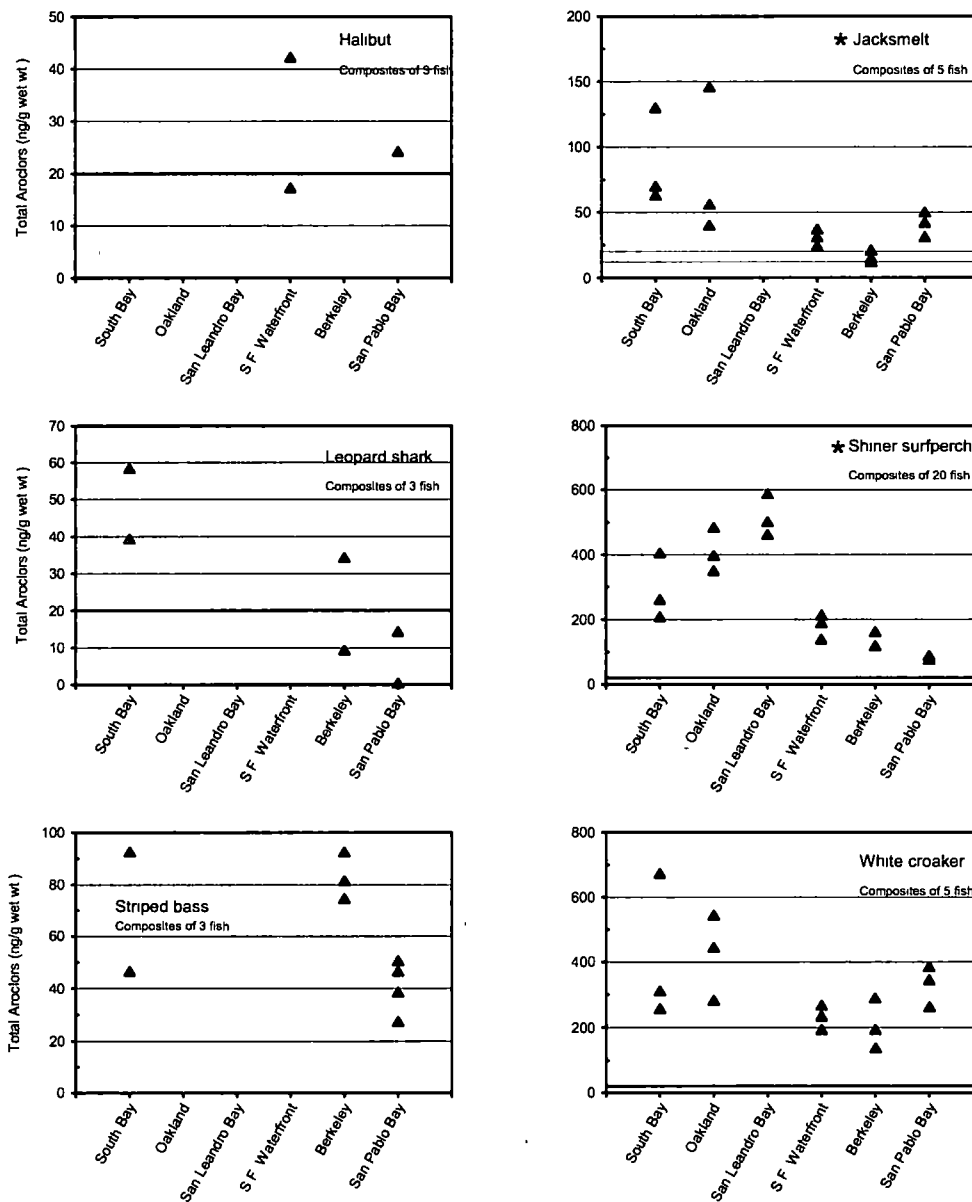
Interestingly, the seasonal variation in PCB concentrations corresponds with similar variation in lipid concentrations. Croaker exhibited highly significant seasonal variation in percent lipids ($R^2 = 0.87$; $p = 0.0006$) with significantly lower values in spring (mean = 1.6 percent) than in the other three seasons (mean = 5.7 percent; Figure 12a). The reduction in spring PCB concentrations may result from reduced tissue lipid content. As we have observed, in the San Francisco Estuary, percent lipid explains significant among-species variation in tissue organochlorine concentrations but not within-species variation for most species (Figure 10). But the range of lipid content is greater in the seasonal croaker sample than for summer sampling of other species. A probable explanation for the seasonal variation in lipid content and PCB concentration is reproductive activity. On the southern California coast, white croaker exhibit peak spawning activity in January and February (Love et al. 1984). Croaker body condition is reduced in early spring as compared to summer, presumably as a result of energy loss due to gonad development and spawning behavior (Love et al. 1984). In our seasonal croaker samples, the gonadal somatic index was much greater in winter and spring than other seasons, indicating reproductive activity in winter and spring (Figure 12e). We hypothesize that croaker sampled in the spring have reduced PCB content because their lipid and PCBs are partitioned to gonad tissue over the course of the winter and spring reproductive period. This hypothesis could be tested by comparing PCB and lipid content of somatic versus gonad tissue on a seasonal basis.

Unlike seasonal variation in croaker PCBs, interannual variation was generally absent for most species. As with mercury, only striped bass exhibited statistically significant variation in PCB concentrations between 1994 and 2000 ($R^2 = 0.67$; $p < 0.0001$). Leopard shark ($R^2 = 0.22$; $p = 0.14$), shiner surfperch ($R^2 = 0.11$; $p = 0.09$), and white croaker ($R^2 = 0.07$; $p = 0.17$) did not exhibit significant patterns. PCB concentrations in striped bass were significantly higher in 1994 than they were in 1997 and 2000 (Figure 7c).

The reduction in striped bass PCB concentrations after 1994 cannot be easily explained by variations in attributes of the sampled fish. As discussed previously, PCB

Figure 11.

PCB concentrations in each sampling location, expressed as sum of Aroclors (ng/g wet), summer, 2000. Triangles are concentrations in each composite sample analyzed. Horizontal line indicates screening value (20 ng/g wet). Asterisk (*) indicates significance of analysis of variance at $p < 0.05$ (Bonferroni corrected). Points at zero indicate results below detection limits. White sturgeon data not included. Note differences in scale.



concentrations are often influenced by lipid content. However, there was no significant variation in striped bass lipid content among the three years (Figure 7d; $R^2 = 0.03$; $p = 0.70$). Some authors have reported significant positive relationships between PCB content and fish size (Stow et al. 1997; Lamon and Stow 1999), but striped bass were significantly smaller in 1994 when PCB concentrations were higher.

One hypothesis for why striped bass PCB concentrations went down after 1994 is that PCB abundance has continued to decrease since the production ban of the 1970s. If this were the case, we would expect concentrations in striped bass to have been higher prior to the 1994 sampling event. In 1979, the Cooperative Striped Bass Study determined PCB Aroclor concentrations ranging from 150 to 650 ng/g. Although these values were generally higher than 1994 values (median total Aroclors equal 182 ng/g), the data comparability is compromised by the fact that the fish selected for analysis were sick fish.

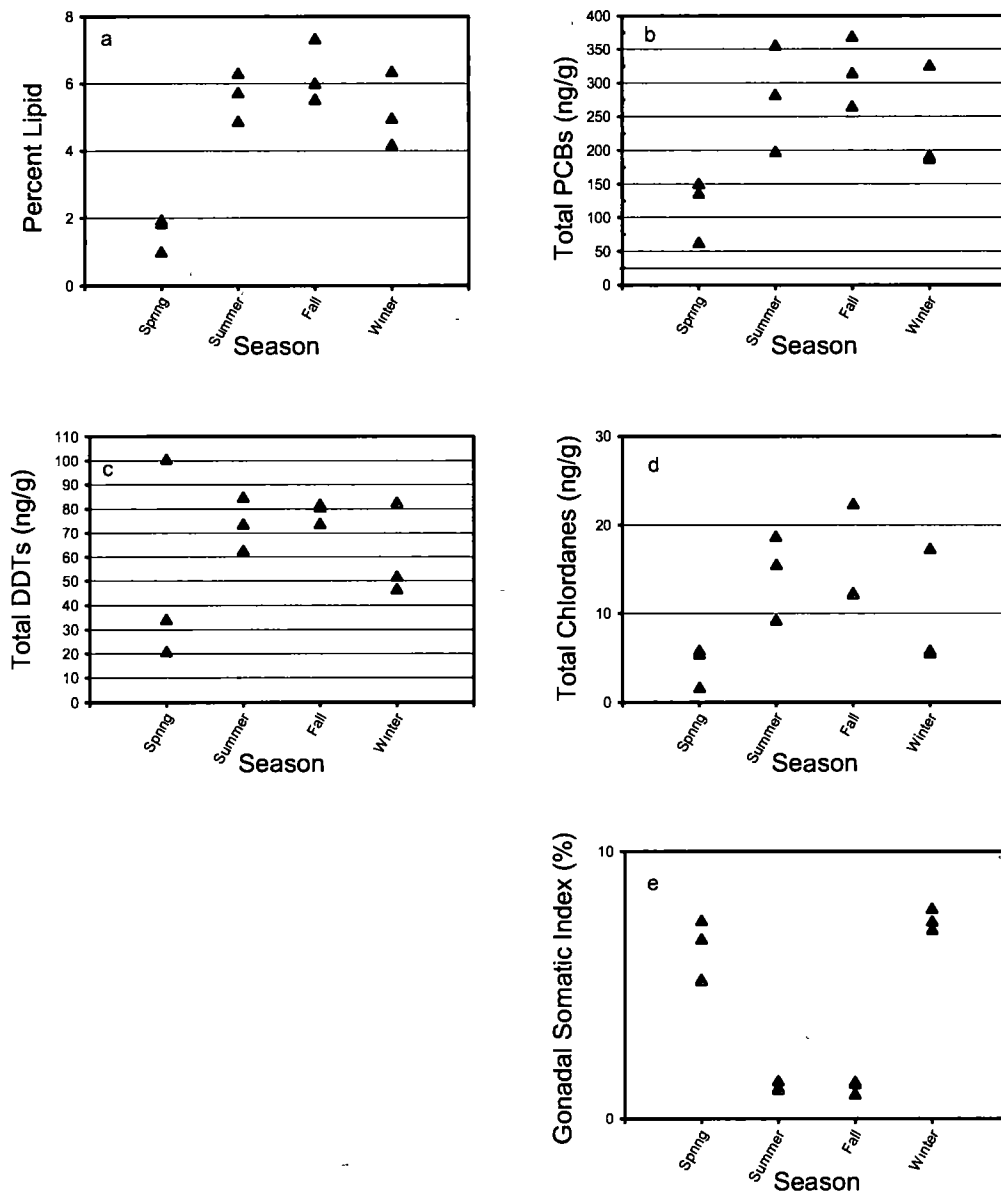


Figure 12. Seasonal variation in attributes of white croaker composite samples collected from Oakland Inner Harbor in 2000. Triangles are concentrations in each composite sample analyzed. a) Tissue lipid content (%). b) PCBs (as sum of congeners; ng/g wet). c) DDTs (ng/g wet). d) Chlordanes (ng/g wet). e) Gonadal somatic index ([gonad mass/whole body mass] * 100).

Examination of TSMP data in combination with RMP and BPTCP data for sturgeon total Aroclor concentrations provides eight years of sampling from 1986 to 2000 (Figure 13a). As with the TSMP striped bass data, these data do not provide clear evidence of a decreasing trend in PCBs in the Estuary food web. Concentrations were elevated in 1989 and 1990, but concentrations were similar in 1986, 1987, and 1992 samples to the samples since 1994. As with wet weight data, lipid weight data also do not demonstrate clear temporal trends (Figure 13b). This apparent lack of trend may partially result from the relatively high detection limits in the TSMP data (50 ng/g wet weight for each Aroclor) and our treatment of non-detects as zero values. Nevertheless, a separate study of liver contaminant concentrations in starry flounder and white croaker didn't find significant PCB trends in most Bay locations between 1984 and 1991 (Stehr et al. 1997).

Finally, the absence of significant interannual variation since 1994 in PCB concentrations for other species does not support the hypothesis that the amount of PCBs available to fish has reduced throughout the Bay. A more likely explanation for the striped bass

and sturgeon interannual variation is that these species exhibit significant interannual variability in their exposure to PCBs between years. This could be due to variation in movement patterns, diets, or populations sampled.

Risebrough (1995) previously observed that PCB concentrations in shiner surfperch collected by the BPTCP (1994 median of 160 ng/g) were close to an order of magnitude lower than samples collected in 1965 (ranging from 400 to 1200 ng/g). It is likely that the 1970s ban of PCB production led to an initial rapid decline followed by a much more gradual decrease, approximating steady-state conditions (Risebrough 1995; Schmitt and Bunck 1995; Stow et al. 1999). Current modeling efforts of PCBs indicate that it will likely take decades for significant reductions of PCBs to occur in Bay sediments and water (Davis 2002). Available evidence does not indicate that PCBs in fish have been declining at a detectable rate over the past decade; if concentrations are continuing to decline, it may take many sampling periods to detect this trend.

DDTs

Introduction

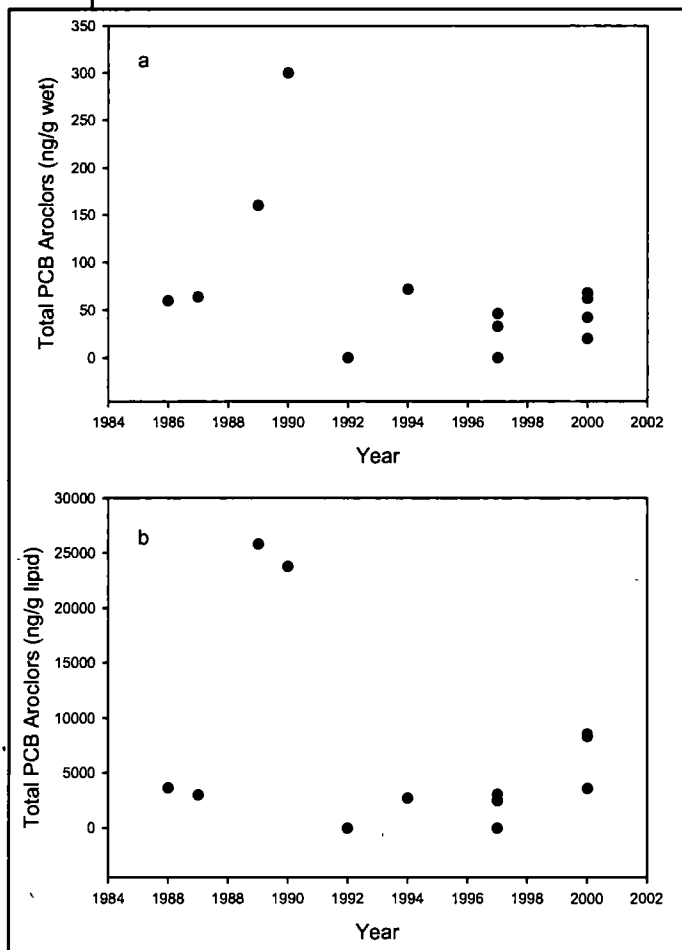
DDT is an organochlorine insecticide that was used very extensively in home and agricultural applications in the U.S. beginning in the late 1940s and continuing in the U.S. until the end of 1972, when all uses,

except emergency public health uses, were cancelled (U.S. EPA 2000). DDT is present as a manufacturing byproduct in technical mixtures of some other pesticides; use of such pesticides containing more than 0.1% DDT was canceled as of December 1988 (U.S. EPA 2000). The primary sources of DDT to the Bay at present are probably continuing transport of contaminated soils and sediments from urban and agricultural sites of historic use, and remobilization of residues from Bay sediments. For the San Francisco Estuary, DDTs are on the 303(d) list of contaminants that impair water quality and must be managed to reduce loading (SFRWQCB 2001).

The terms DDT or DDTs are often used to refer to a family of isomers (i.e., *p,p'*-DDT and *o,p'*-DDT) and their breakdown products (*p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD). DDT data are often expressed as the sum of these six components, and this approach is recommended by U.S. EPA (2000). DDT and its metabolites DDE and DDD are neurotoxic and are also classified by U.S. EPA as probable

human carcinogens (U.S. EPA 2000). Like PCBs, DDTs are very persistent in the environ-

Figure 13. Long-term patterns in white sturgeon total PCB concentrations (Aroclor basis; ng/g). Each data point represents a composite sample of 2 to 6 sturgeon. Data were obtained from the Toxic Substances Monitoring Program (1986 through 1992) and the Regional Monitoring Program (1994 through 2000). a) Wet weight Aroclor concentration (ng/g). b) Lipid weight Aroclor concentration (ng/g lipid tissue).



ment, resistant to metabolism, have a strong affinity for lipid, and biomagnify in aquatic food webs (Gobas et al. 1993, Suedel et al. 1994).

Analytical considerations

Seven DDT compounds (isomers and metabolites) were analyzed and reported. Following U.S. EPA (2000) guidance, six of these compounds were summed to derive "sum of DDTs": *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD. The screening value for DDTs (100 ng/g wet) applies to this sum of DDTs. Detectable DDT compounds were present in 79 of the 80 samples analyzed. Detection limits for these compounds ranged from 2 to 5 ng/g wet (Appendix Table 1c).

To best approximate normal distribution, DDT data were log transformed for the spatial and seasonal analysis of variance and were square root transformed for the analysis of interannual variation.

To understand the potential confounding effect of growth attributes on interannual variation in DDTs, we performed stepwise regression analyses on two species that exhibited interannual trends (white croaker and shiner surfperch) (Draper and Smith 1998). Potential predictor variables were length and percent lipid, in addition to categorical variables for each of the three years examined (1994, 1997, and 2000). Both forward selection and backwards elimination methods were employed, with $\alpha = 0.05$ required to retain individual predictors; all results reported were consistent among these two methods. Graphical analyses were also conducted to corroborate these methods. Additionally, standard diagnostic plots of residuals were examined for normality and heteroscedasticity and data were log transformed, when necessary (Draper and Smith 1998). This resulted in log transformation of DDT concentrations for both species, and also of length in the shiner surfperch analysis.

As with PCBs, few data were collected on DDT concentrations in fish in San Francisco Bay prior to 1994. Risebrough (1969) determined DDTs in the same three shiner surfperch samples he analyzed for PCBs. The Toxic Substances Monitoring Program (TSMP) analyzed the same fish as for PCBs (refer to the PCBs analytical considerations section for descriptions of these analyses) (Rasmussen and Blethrow 1991; Rasmussen 1993, 1995).

Data distribution and summary statistics

Sum of DDT concentrations were highest in white croaker, with a median concentration of 61 ng/g wet, and shiner surfperch, with a median of 37 ng/g wet (Table 2, Figure 14). Concentrations were intermediate in jacksmelt and striped bass (median of 21 and 23 ng/g wet, respectively), and 13 ng/g wet or lower in the other species. Leopard shark had the lowest median concentration (5.1 ng/g wet). Sum of DDT concentrations were above the screening value of 100 ng/g wet in only three of 80 samples (4%), all of them white croaker (Table 3).

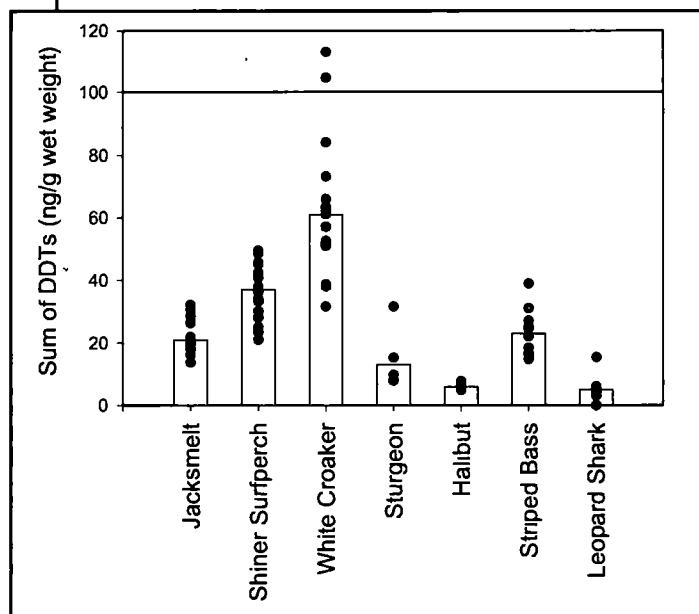
Controlling factors

Sum of DDT concentrations in the seven species sampled were closely correlated ($R^2 = 0.65$, $p < 0.0001$) with lipid content (Figure 10b). As observed for the other trace organics, the fish species with the highest lipid content in their muscle tissue had the highest DDT concentrations. However, individual variation in lipid content within a given species was not always related to DDT concentrations. The correlation of DDT with lipid was the strongest observed for the trace organics analyzed. As observed for PCBs, stable isotope evidence indicated no apparent relationship between DDT concentrations and fish trophic position (Greenfield et al. In Review).

Spatial patterns

Unlike mercury, PCBs, or chlordanes, concentrations of DDTs were fairly similar among sites (Figure 15). Wet weight DDT concentrations did not exhibit significant spatial patterns for jacksmelt, shiner surfperch, white croaker, or striped bass. For example, jacksmelt site mean concentrations ranged from 17 to 26 ng/g wet (Table 4), whereas mean PCB concentrations varied fivefold among sites. The spatial trends that were present were also inconsistent with other contaminant trends. For example, al-

Figure 14. DDT concentrations in Bay fish, expressed as sum of DDTs (ng/g wet), summer, 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Horizontal line indicates screening value (100 ng/g wet).



though not statistically significant, jacksmelt at Oakland Harbor had the lowest mean DDT concentrations of any site, as compared to the highest mean PCB concentrations. Variation was distinct among species as well. For shiner surfperch, San Pablo Bay had the lowest mean concentrations. In contrast, San Pablo Bay white croaker had the highest mean concentrations (Figure 15; Table 4).

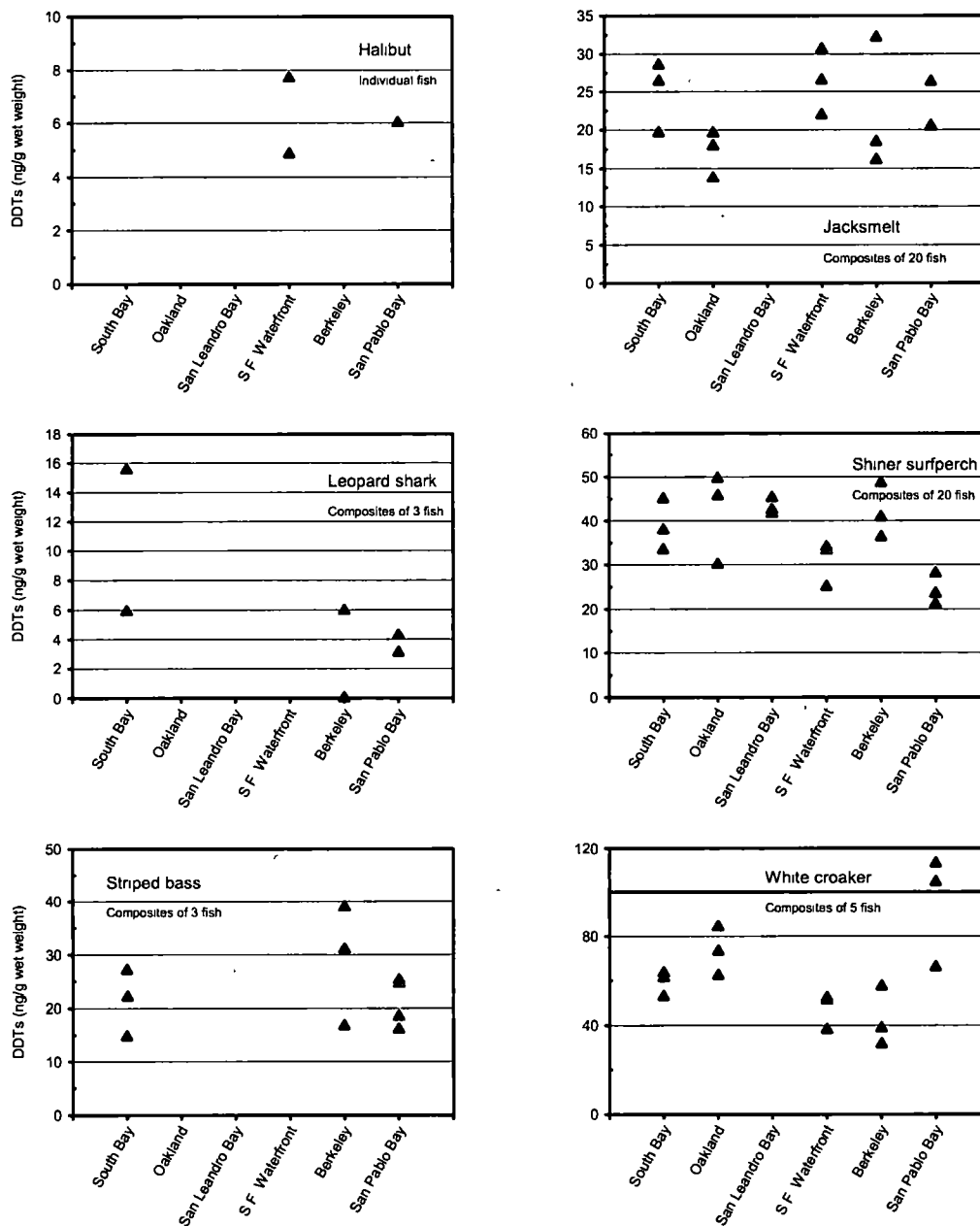
The lack of spatial variation exhibited for DDTs may reflect their differing sources from other organochlorine compounds. DDTs were primarily used as pesticides in agricultural areas. Therefore, their distribution would be

expected to correlate with agriculture. In contrast, PCBs were mostly used in industrial applications and chlordanes to control residential pests. Interpretations of RMP results indicate that spatial distribution patterns of DDTs in sediments or water are fairly similar to patterns for PCBs and chlordanes, with elevated concentrations in the South Bay and reduced concentrations in the Central Bay (e.g., Leatherbarrow et al. 2002). The spatial variation in sediment and water column concentrations creates the potential for spatial variation in fish. In the case of DDTs, small-scale movement of fish may dampen any impact of spatial variation in prey concentrations, though it remains unclear why PCBs and mercury show spatial patterns but DDTs don't.

Temporal trends

In 2000, white croaker did not exhibit significant seasonal variation in DDT concentrations (ANOVA $R^2 = 0.33$; $p = 0.34$). Concentrations were relatively low in spring for two of the three composites but the other composite exhibited the highest concentration of all twelve seasonal samples (Figure 12c). The lack of statistically significant seasonal variation in DDT concentrations, despite significant variation in PCB and lipid concentrations (and, as we shall see, chlordanes concentrations), provides another example that DDT behavior is somewhat different from other trace organic contaminants.

Estuary fish exhibited significant interannual variation in total DDT concentrations. Of the four species sampled over the three periods, significant interannual variation in DDT concentrations was observed for striped bass ($R^2 = 0.41$; $p = 0.0012$), shiner surfperch ($R^2 = 0.36$; $p = 0.0001$), and white croaker ($R^2 = 0.23$; $p = 0.0012$). Only leopard shark ($R^2 = 0.24$; $p = 0.12$) did not exhibit significant interannual variation in DDT concentrations. The direction of changes over time varied among species. In both shiner surfperch

**Figure 15.**

DDT concentrations in each sampling location, expressed as sum of DDTs (ng/g wet), summer, 2000. Triangles are concentrations in each sample analyzed. Horizontal line indicates screening value (100 ng/g wet). Points at zero indicate results below detection limits. White sturgeon data not included. Note differences in scale.

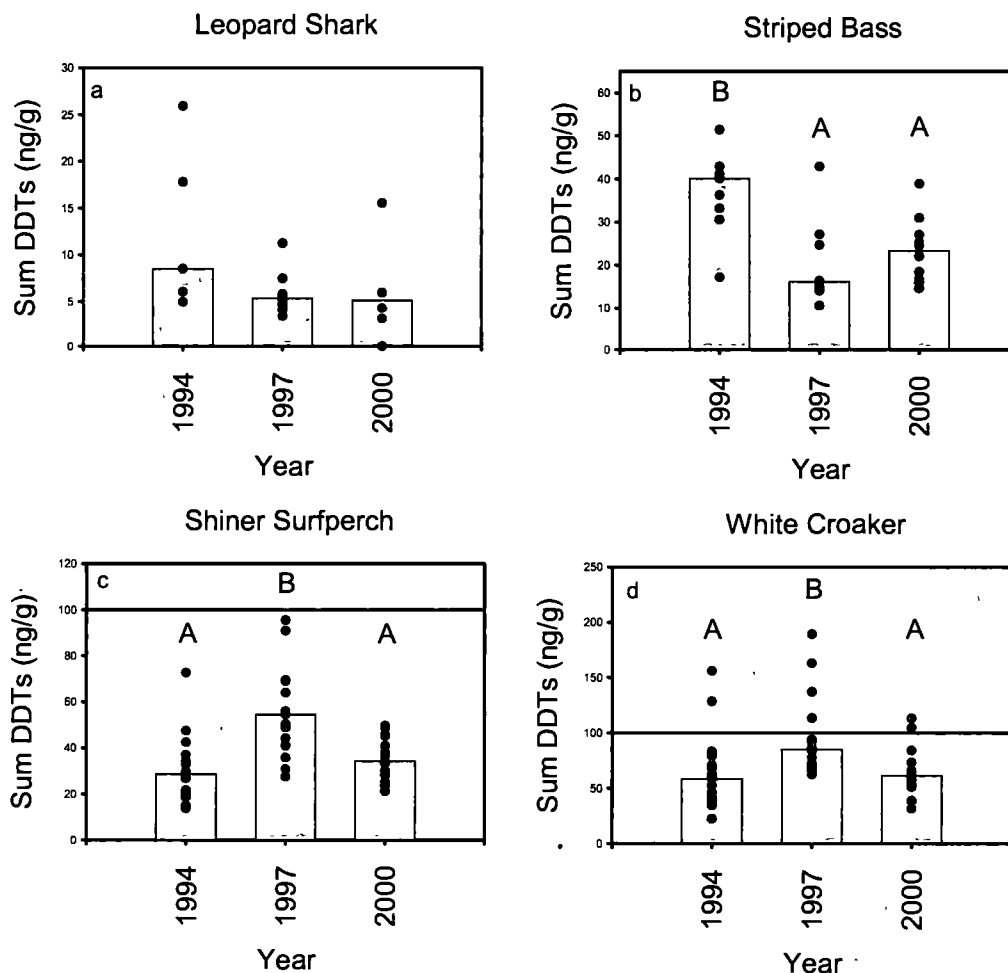
and white croaker, concentrations were significantly higher in 1997 than in 1994 or 2000 (Figure 16c, 16d). In contrast, striped bass exhibited significantly elevated concentrations in 1994 as compared to the other two years (Figure 16b).

Variation in fish attributes such as length or lipid content may explain why DDTs were elevated in 1997 for shiner surfperch and white croaker. Stepwise regression analysis of length, lipid and year effects was conducted to test this hypothesis.

For DDT concentrations in shiner surfperch, there was a significant positive effect of length (partial $R^2 = 0.09$; $p = 0.019$; $N = 43$) and a significant positive effect for samples collected in 1997, as compared to 1994 and 2000 (partial $R^2 = 0.32$; $p < 0.0001$). Once length effects were taken into account, there was no significant relationship between percent lipid and DDTs in shiner surfperch. These results indicate, that once length effects

Figure 16.

Change in total DDTs (ng/g wet) over consecutive RMP sampling periods. Points are concentrations in each sample analyzed. Bars indicate median concentrations. Horizontal line equals screening value (100 ng/g). Capital letters indicate statistically significant years by ANOVA ($p < 0.05$; Bonferroni corrected for multiple comparisons). a) Leopard shark. b) Striped bass. c) Shiner surfperch. d) White croaker.



are taken into consideration, shiner surfperch still exhibit elevated DDT concentrations in 1997. Scatter plots of the data show elevated 1997 concentrations at a given length or lipid content (Figures 17a and 17b).

For DDT concentrations in white croaker, there was a significant positive effect of both length (partial $R^2 = 0.23$; $p < 0.0001$; $N = 53$) and percent lipids (partial $R^2 = 0.40$; $p < 0.0001$). There was also a statistically significant but very weak negative effect for samples collected in 2000, as compared to other years (partial $R^2 = 0.04$; $p = 0.017$). Graphical analyses indicate that the significantly elevated concentrations observed in 1997 (Figure 16d) result from the fact that 1997 fish are higher in lipid content than other years (Figure 17d).

Our statistical and graphical evaluation of interannual differences in DDTs suggests that patterns that originally appeared to be consistent among species may stem from different mechanisms. ANOVA indicated that both shiner surfperch and white croaker had significantly elevated concentrations of DDT in 1997 (Figures 16c and 16d). However, the stepwise regression indicated that only shiner surfperch had significantly higher concentrations in that year after potential growth effects (i.e. differences in length and lipid) were accounted for. This finding demonstrates the importance of collecting and evaluating growth attributes to help determine why fish concentrations fluctuate between years.

DDT concentrations in shiner surfperch have declined since Risebrough's 1965 sampling. Concentrations at that time (1000 - 1400 ng/g) were more than an order of

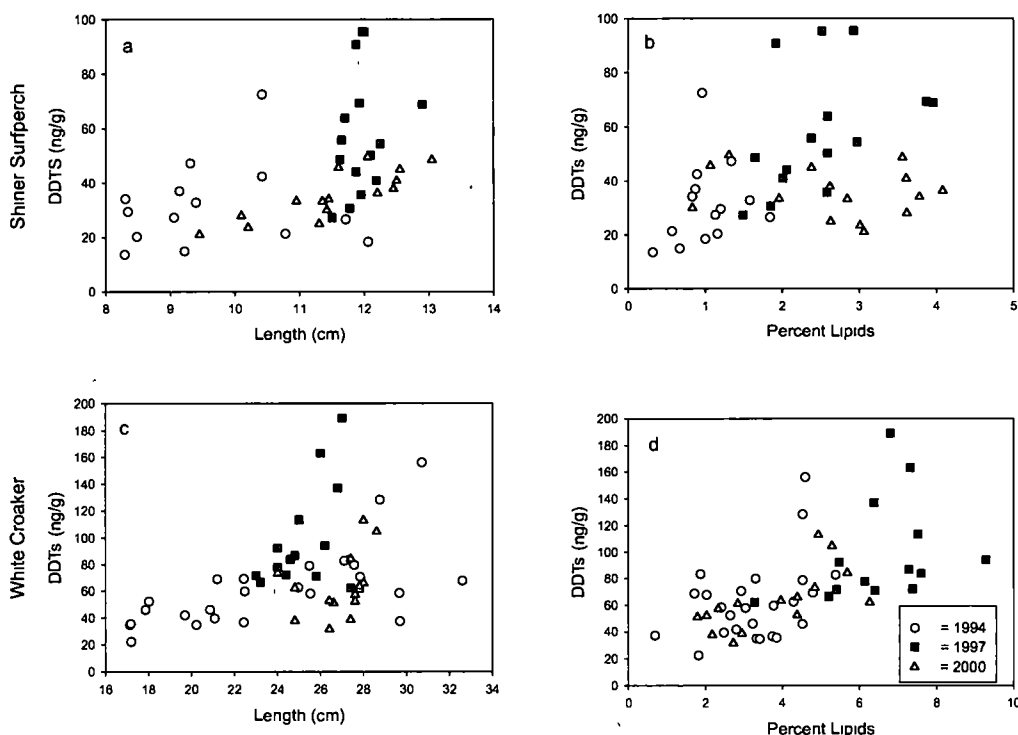


Figure 17. Total DDTs (ng/g wet) versus length (cm) and lipids (%) in selected fish species. Data taken from 1994 (circles), 1997 (squares) and 2000 (triangles). a) Length versus DDTs in shiner surfperch. b) Lipids versus DDTs in shiner surfperch. c) Length versus DDTs in white croaker. d) Lipids versus DDTs in white croaker.

magnitude greater than concentrations in 1994, 1997 and 2000 (median concentrations of 29, 54, and 34 ng/g, respectively). When data since 1994 are combined with TSMP data, DDT concentrations in white sturgeon also appear to be declining (Figure 18a). These patterns are not due to reduction in length. Additionally, lipid weight DDT concentrations exhibit a similar pattern, with concentrations dropping after 1994 (Figure 18b). Although each TSMP data point consists only of a single composite of four to six fish, the observed pattern is highly suggestive of a decline in DDT concentrations in sturgeon since the mid-1980s.

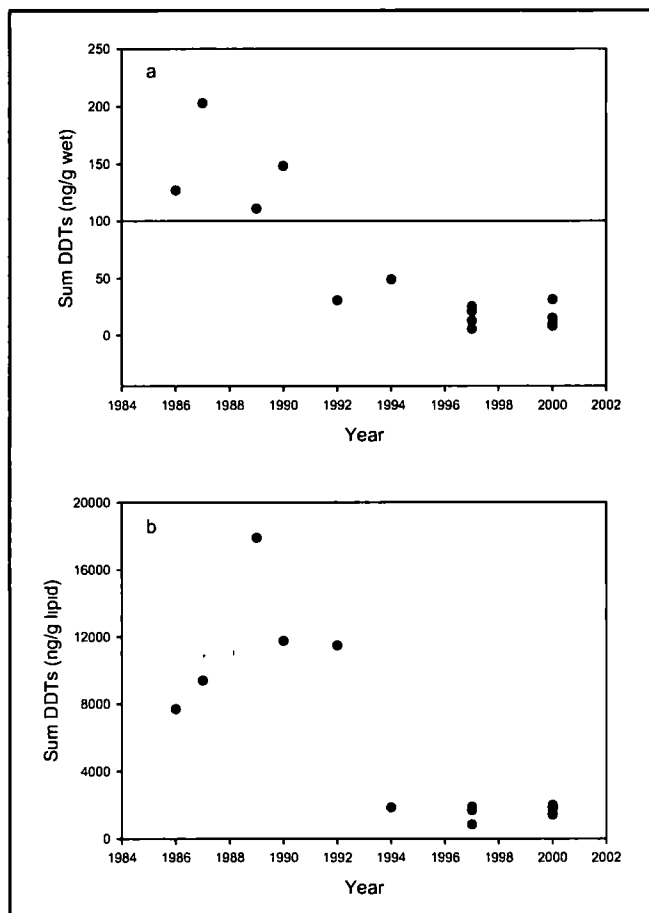
Chlordanes

Introduction

Chlordane is another organochlorine insecticide that was used extensively in home and agricultural applications (including corn, grapes, and other crops) in the U.S. for the control of termites and many other insects (Shigenaka 1990; U.S. EPA 2000). Like PCB, chlordane is a term that represents a group of a large number (140) of individual compounds (Dearth and Hites 1991). Restrictions on chlordane use began in 1978, and domestic sales and production ceased in 1988 (Shigenaka 1990; U.S. EPA 2000). An estimated 70,000 tons of technical chlordane were produced from 1946 until 1988 (Dearth and Hites 1991). As for DDT, the primary sources of chlordane to the Bay are probably continuing transport of soils and sediments from urban and agricultural sites of historic use and remobilization of residues from Bay sediments. For the San Francisco Estuary, chlordanes are on the 303(d) list of contaminants that impair water quality and must be managed to reduce loading (SFRWQCB 2001).

Chlordane data are usually expressed as the sum of several of the most abundant and persistent components and metabolites of the technical chlordane mixture. Chlordane is neurotoxic and is classified by U.S. EPA as a probable human carcinogen (U.S. EPA 2000). Like PCBs and DDT, chlordane compounds are very persistent in the environ-

Figure 18. Long-term patterns in white sturgeon total DDT concentrations (ng/g). Each data point represents a composite sample of 2 to 6 sturgeon. Horizontal bar represents screening value (100 ng/g). Data were obtained from the Toxic Substances Monitoring Program (1986 through 1992) and the Regional Monitoring Program (1994 through 2000). a) Wet weight DDT concentration (ng/g). b) Lipid weight DDT concentration (ng/g lipid tissue).



analysis of spatial variation in chlordane concentration. Specifically, the Median and Wilcoxon procedures, both based on simple linear rank statistics, were used. When data from 1994 through 2000 were combined, the proportion of non-detects was lower (19 of 198 samples analyzed), which facilitated normal approximation to the degree required for parametric analysis of variance (Sokal and Rohlf 1995). For analysis of interannual variation, chlordane data were square root transformed to approximate normal distribution.

As with PCBs and DDTs, few data were collected on chlordane concentrations in fish in San Francisco Bay prior to 1994. The Toxic Substances Monitoring Program (TSMP) analyzed the same fish as for PCBs and summed chlordanes in the same fashion as the RMP (refer to the PCBs analytical considerations section for descriptions of these samples) (Rasmussen and Blethrow 1991; Rasmussen 1993, 1995).

Data distribution and summary statistics

Sum of chlordanes concentrations were highest in white croaker, with a median concentration of 9.4 ng/g wet (Table 2, Figure 19). Shiner surfperch had the second highest median concentration (8.1 ng/g wet). The other species sampled had median concentrations of 1.3 ng/g wet or less. Leopard shark and California halibut had the lowest concentrations; for both species, the median concentrations were below detection. None of the 80 samples exhibited sum of chlordane concentrations above the 30 ng/g screening value.

ment, resistant to metabolism, have a strong affinity for lipid, and biomagnify in aquatic food webs (Suedel et al. 1994).

Analytical considerations

Nine chlordane compounds (components of the technical mixture and metabolites) were analyzed. Five of these compounds were summed to derive "sum of chlordanes": cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. The screening value for chlordanes (30 ng/g wet) applies to this sum. The four remaining chlordane compounds (heptachlor, heptachlor epoxide, cis-chlordene, and trans-chlordene) were not detected in any sample. Detectable chlordane compounds were present in 63 of the 80 samples analyzed. Detection limits for the chlordanes of interest were 1 to 2 ng/g wet (Appendix Table 1c).

Due to the relatively large number of non-detects (17 of 80 samples analyzed), nonparametric methods were used for statistical

Controlling factors

Sum of chlordanes concentrations in the seven species sampled were significantly correlated ($R^2 = 0.33$, $p < 0.0001$) with lipid content (Figure 10c). As observed for the other trace organics, the fish species with the highest lipid content in their muscle tissue had the highest chlordanes concentrations. The lower correlations observed for chlordanes when compared to other contaminants may derive from the fact that chlordanes concentrations were relatively close to detection limits, leading to reduced accuracy and precision.

Spatial patterns

Chlordane patterns were generally similar to those for mercury and PCBs but were not statistically significant using Bonferroni protection combined with nonparametric methods. Using the Wilcoxon scores (Kruskal-Wallis test), the uncorrected p values for significance of spatial pattern were 0.03 for jacksmelt and 0.013 for surfperch. As observed for PCBs, concentrations in jacksmelt and shiner surfperch tended to be higher at South Bay, San Leandro Bay, and Oakland Harbor and relatively low at San Francisco Waterfront and Berkeley (Table 4; Figure 20). Chlordanes in San Leandro Bay were 12 times those in San Francisco Waterfront for shiner surfperch (though still below the screening value).

Temporal trends

In 2000, white croaker exhibited marginally significant seasonal variation in chlordanes concentrations (ANOVA $R^2 = 0.61$; $p = 0.048$). As with PCBs, concentrations were relatively low in spring (mean = 4.2 ng/g), as compared to other sampling seasons (mean = 13.1 ng/g; Figure 12d). As with PCBs, the seasonal variation in chlordanes concentrations corresponds with similar variation in lipid concentrations. Therefore, the reduction in spring chlordanes concentrations likely results from reduced tissue lipid content, associated with spawning activity (please refer to the PCBs section for more discussion of this relationship).

Unlike the other contaminants, sum of chlordanes exhibited a decrease in concentrations among the three years sampled since 1994. A statistically significant pattern was observed for striped bass ($R^2 = 0.73$; $p < 0.0001$) and white croaker ($R^2 = 0.26$; $p = 0.0005$). Leopard shark also exhibited a downward trend ($R^2 = 0.49$; $p = 0.0043$). For all three species, 2000 was significantly lower than 1994 and 1997 (Figure 21). Striped bass also exhibited a significant decline from 1994 to 1997. Median concentrations in white croaker did increase from 1994 to 1997, but this change was not significant (Figure 21d). Only shiner surfperch did not exhibit significant variation among years ($R^2 = 0.12$; $p = 0.08$).

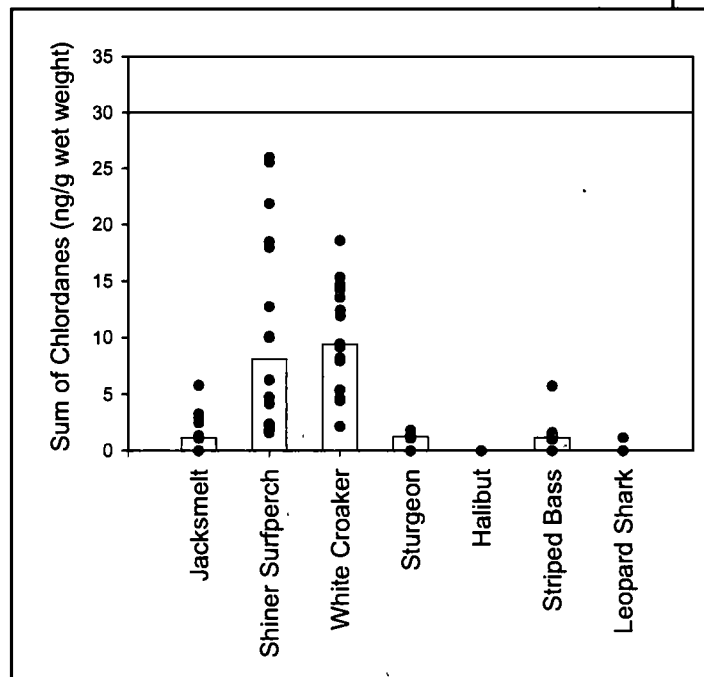
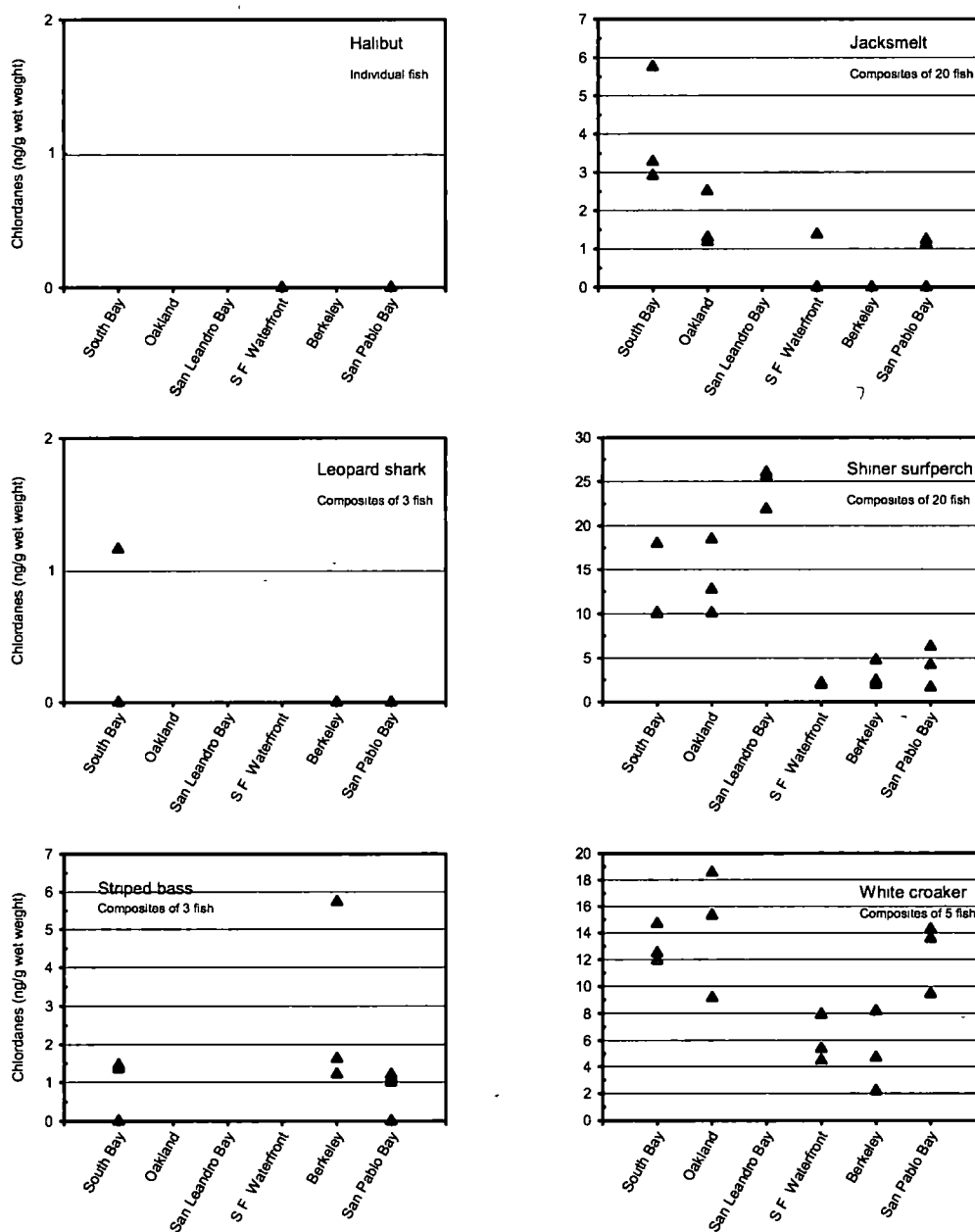


Figure 19. Chlordane concentrations in Bay fish, expressed as sum of 5 chlordanes (ng/g wet), summer 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Horizontal line indicates screening value (30 ng/g wet).

Figure 20. Chlordane concentrations in each sampling location, expressed as sum of 5 chlordanes (ng/g wet), summer, 2000. Triangles are concentrations in each sample analyzed. Points at zero indicate results below detection limits. White sturgeon data not included. Note differences in scale.



When white sturgeon chlordane concentrations were compared between the TSMP (1986 through 1992) and the BPTCP/RMP data (1994 through 2000), a clear decline in concentrations was not evident (Figure 22a). However, for these fish, chlordane concentrations were significantly related to percent lipid (linear regression of log transformed data; $n = 13$; $R^2 = 0.53$; $p = 0.0033$). When the residuals of the log chlordane versus log lipid relationship were plotted, a general declining trend became apparent (Figure 22b). Although this data set is limited in sample size, the pattern suggests that when chlordane concentrations are corrected for tissue lipid content, concentrations have been declining in sturgeon since the mid-1980s.

If chlordane concentrations in fish are indeed decreasing, this may be a result of the recent use history of this suite of compounds. The use of chlordanes in the United States was not eliminated until 1988. In fact, overall use in California exhibited a dramatic increase in 1986 and 1987 (when compared to the previous decade), followed by an

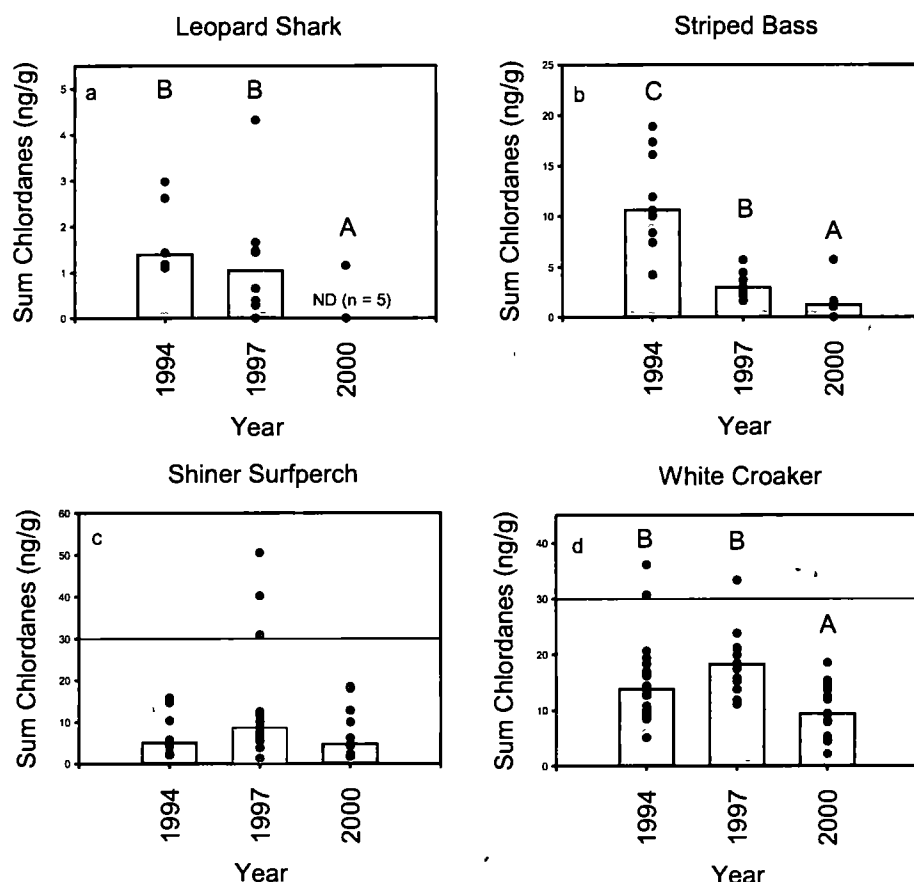


Figure 21. Change in chlordanes (ng/g wet) over consecutive RMP sampling periods. Points are concentrations in each sample analyzed. Bars indicate median concentrations. Horizontal line equals screening value (30 ng/g). Capital letters indicate statistically significant difference in years by ANOVA ($p < 0.05$; Bonferroni corrected for multiple comparisons). a) Leopard shark. b) Striped bass. c) Shiner surfperch. d) White croaker.

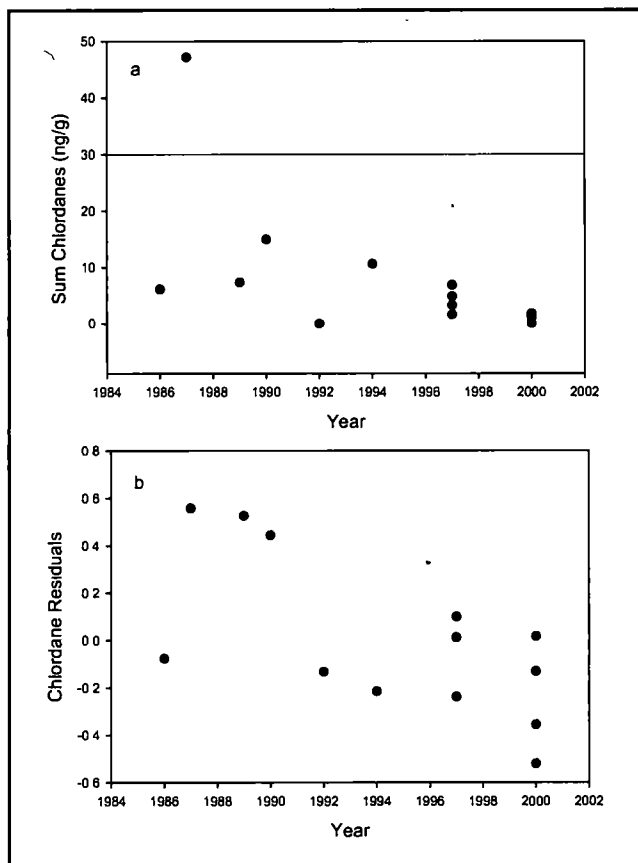
abrupt decline in 1988 (Shigenaka 1990). In contrast, PCB use was banned by 1979 and most mercury use ended before the 20th century. In general, after a suite of compounds is banned, contamination in fish and wildlife exhibits an initial rapid decline followed by a much more gradual decrease (Risebrough 1995; Schmitt and Bunck 1995; Stow et al. 1999). We found a decreasing trend in chlordanes in three of four fish species after only three sampling periods. A separate study of starry flounder and white croaker generally did not observe declining liver tissue chlordane concentrations in the 1980s (Stehr et al. 1997). The observation of declines in the 1990s (Figure 21, 22b) but not the 1980s (Stehr et al. 1997) may indicate that chlordanes entered a rapidly declining phase shortly after use curtailment in the late 1980s. PCBs and mercury, in contrast, are not likely to still be in a rapidly declining phase (Risebrough 1995). Literature also suggests that, when compared to PCBs, chlordanes have higher water solubility, creating the potential for volatilization, and higher degradation rates (Howard 1991; Mackay et al. 1992). The relative importance of degradation, volatilization, and source reduction could be compared by mass balance modeling of chlordane fate in the Estuary (Davis 2002). Of course, continued monitoring will be required to ascertain whether current declines are indicative of long-term trends.

Dieldrin

Introduction

Dieldrin is an organochlorine insecticide that was widely used in the U.S. from 1950 to 1974, primarily on termites and other soil-dwelling insects, as a wood preservative, in moth-proofing clothing and carpets, and on cotton, corn, and citrus crops (U.S. EPA 2000). Restrictions on dieldrin use began in 1974. Most uses in the U.S. were banned in

Figure 22. Long-term patterns in white sturgeon chlordane concentrations (sum of 5 chlordanes). Each data point represents a composite sample of 2 to 6 sturgeon. Data were obtained from the Toxic Substances Monitoring Program (1986 through 1992) and the Regional Monitoring Program (1994 through 2000). a) Wet weight chlordane concentrations (ng/g). Horizontal bar represents screening value (30 ng/g). b) Lipid-corrected chlordane concentrations. The y-axis is the residual variation in chlordane concentrations from a chlordane versus tissue lipid regression.



1985. Dieldrin use for underground termite control continued until voluntarily canceled by industry in 1987 (U.S. EPA 2000).

Unlike the other trace organic contaminants discussed in this report, which represent groups of chemicals, dieldrin is a single chemical. Dieldrin is neurotoxic and is also classified by U. S. EPA as a probable human carcinogen (U.S. EPA 2000). It is on the 303(d) list of contaminants that impair water quality of the San Francisco Estuary (SFRWQCB 2001). Similar to the other organochlorines described, dieldrin is very persistent in the environment, resistant to metabolism, has a strong affinity for lipid, and readily accumulates in aquatic food webs.

Analytical considerations

Detectable dieldrin was only present in 15 of the 80 samples analyzed (19%). The detection limit for dieldrin was 2 ng/g wet, which is equivalent to the screening value.

Dieldrin concentrations in the fish

species sampled were below or close to the detection limit, and consequently the precision of these measurements is lower than for the other organics discussed in this report. Because the dieldrin results were mostly below detection limits, data were evaluated using graphical analysis only.

Data distribution and summary statistics

For dieldrin, the detection limit and screening value are equal (2 ng/g). Although most fish samples were below the detection limit for dieldrin, white croaker appeared to have the highest concentrations (Figure 23). When the seasonal study was included, 12 of the 24 white croaker samples were above the detection limit and screening value (Table 3). Shiner surfperch occasionally exhibited detectable concentrations but the majority of samples (15 of 18) were below detection, and therefore below the screening value. All samples from all other species were below detection.

Controlling factors

Because the majority of samples were below detection for dieldrin, it is difficult to evaluate controlling factors. Nevertheless, the only species exhibiting concentrations above detection were shiner surfperch and white croaker. The species have the highest average lipid content of all species analyzed. Therefore, as observed for the other trace organics, the fish species with the highest lipid content in their muscle tissue had the highest dieldrin concentrations.

Spatial patterns

Distinct spatial patterns were observed for dieldrin in that only certain sites exhibited concentrations above the detection limit. For white croaker, all three summer samples exceeded the detection limit in Oakland Harbor (median concentration of 2.3 ng/g) and two of three samples exceeded the detection limit in South Bay Bridges (both at 2.3 ng/g). For shiner surfperch, all three San Leandro Bay samples exceeded the detection limit (median concentration of 2.4 ng/g).

Temporal trends

For dieldrin, temporal trend evaluation was hampered by the higher detection limits in 2000 than in previous years. For all species excepting croaker, concentrations in 1997 were below present detection limits, precluding comparison among years. Wet weight concentrations of dieldrin in white croaker were lower in 2000 (median below the detection limit of 2 ng/g) than in 1997 (median = 4.5 ng/g) or 1994 (median = 2.6 ng/g). Croaker lipid content was not significantly different between 1994 and 2000, suggesting that the decline in 2000 does not derive from changes in tissue lipid content. In a NOAA study, starry flounder and white croaker exhibited declining dieldrin concentrations from 1984 to 1991 at three distinct Bay locations (Stehr et al. 1997), supporting the hypothesis that dieldrin concentrations in fish declined in recent decades.

PBDEs

Introduction

Polybrominated diphenyl ethers (PBDEs) are used as flame retardants in plastics, textile coatings, and polyurethane foams (Oros and David 2002). Although their use is restricted in Europe, they are not regulated in the United States and are very actively used. Therefore, they are commonly released into the natural environment via pathways including municipal waste disposal, incineration, leaching, and volatilization. PBDEs are similar in their chemical properties to PCBs. Like PCBs, they are hydrophobic and lipophilic, they tend to bioaccumulate in tissue, and they biomagnify in the food web (Darnerud et al. 2001).

PBDEs constitute a potential environmental threat because they are not regulated in the United States, they occur at elevated and increasing levels in environmental samples, and they may be toxic to humans and wildlife. The concentrations of PBDEs in European sediments and biota have increased since the early 1970s (Darnerud et al. 2001). A recent Virginia study found concentrations in carp to be the highest edible fish tissue concentrations ever reported (Hale et al. 2001). Their presence has also been documented in the San Francisco Estuary. Tetrabromo diphenyl ether, pentabromo diphenyl ether, and hexabromo diphenyl ether have all been identified in Estuary water samples collected in 1993 or 1994 (Oros and David 2002). Furthermore, concentrations are elevated in harbor seal blubber and in breast tissue of Bay Area women (She et al. 2002), indicating significant bioaccumulation, biomagnification, and human exposure in this region. Because of the potential health hazard and environmental threat posed by PBDEs, the San Francisco

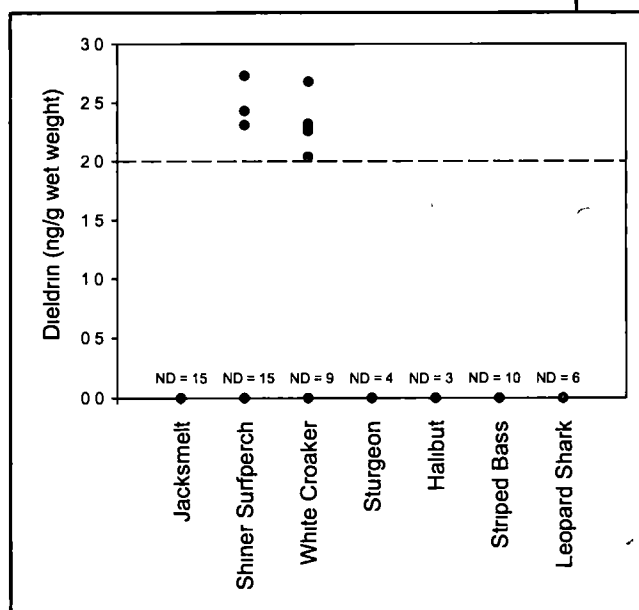


Figure 23. Dieldrin concentrations in Bay fish (ng/g wet), summer 2000. Points are concentrations in each composite sample analyzed. Dotted line indicates screening value and also detection limit (2 ng/g wet). Note that the majority of samples are below detection limits (ND).

Bay Regional Water Quality Control Board has recently added them to a 303(d) watch list of contaminants that may be causing impairment of the Estuary (SFRWQCB 2001).

Research on the toxicological properties of PBDEs has been limited. Nevertheless, some evidence suggests that PBDEs have adverse impact on animals. At high exposure levels, adult animals exhibit increased development of cancerous tumors. Additionally, PBDEs may negatively impact fetal development. Developmental consequences of fetal exposure in laboratory animals include neurological effects, effects on thyroid development, and impacts on adult behavior (Darnerud et al. 2001; de Wit 2002). U.S. EPA has not developed screening values for PBDEs.

In the 2000 fish samples, polybrominated diphenyl ethers were discovered as large peaks in the electron capture detection gas chromatography results. Their analysis was not planned for the 2000 fish monitoring program, but their subsequent discovery and identification in the chromatographs, combined with their potential to produce adverse effects, prompted their inclusion in this report. Their inclusion is part of a broader effort to initiate surveillance monitoring of contaminants that are not currently regulated but are present in the Bay and may have adverse effects (Oros and Taberski 2002). The compounds analyzed in fish tissue are BDE 47 (2,2',4,4'-tetrabromo diphenyl ether), BDE 99 (2,2',4,4',5-pentabromo diphenyl ether), and BDE 153 (2,2',4,4',5,5'-hexabromo diphenyl ether). These three PBDEs are more bioaccumulative than more highly brominated compounds (Andersson and Blomkvist 1981; Darnerud et al. 2001) and are major constituents of commercial flame retardants. They were selected for monitoring because examination of chromatogram peaks identified them in the fish samples.

Analytical Considerations

Three PBDE compounds were identified and analyzed in fish tissues: BDE 47, BDE 99, and BDE 153. The sum of these three was taken and reported as sum of PBDEs. As for PCBs and pesticides, these PBDE analyses were conducted using electron capture detection gas chromatography (ECD-GC) and analysis. All PBDE values are reported as estimated results because they weren't originally included in the monitoring plan, and their discovery in the fish samples was unanticipated, causing many of the analytical procedures to be non-standard.

Several factors warrant reporting the PBDE results as estimated values. First of all, the standards were analyzed several weeks after the samples. Secondly, sample extracts were not diluted and reanalyzed if they were outside of the calibration range. Third, the lab that reported these data (Water Pollution Control Laboratory, CDFG, Rancho Cordova) had not performed method validation or matrix fortifications studies prior to these analyses. Finally, comparison of results with another lab raised into question their reliability. Of the 80 samples analyzed for PBDEs, 15 were also separately analyzed at the Hazardous Materials Laboratory, Cal/EPA, (HML) using gas chromatography coupled with mass spectroscopy. The results we report were generally 1.3 to 3.0 times the results determined by HML. The major source of discrepancy was BDE 47, for which the reported concentration was 2 through 10 times the concentration determined by HML. BDE 99 and BDE 153 were more comparable. In response to the discrepancy for BDE 47, the Water Pollution Control Laboratory performed a sample-standard coinjection, which indicated that coelution did not appear to be occurring. They also reanalyzed three of the original samples for BDE 47 using GC-MS. The relative percent deviation between the original ECD-GC and the new GC-MS results was small (8%), suggesting that the ECD-GC successfully quantified this compound.

We present and analyze the PBDE data despite the fact that they are only semi-quantitative because of the significance of finding these compounds in Bay fish. Nevertheless, we strongly advise against treating these data as quantitative beyond the rudimentary summary that follows. The RMP 2003 fish data will include analysis of PBDEs

using methodologies appropriate to generate quantitative data. Currently, there are no screening values with which to compare PBDE tissue concentrations.

Data distribution and summary statistics

Sum of PBDEs concentrations were highest in white croaker, with a median concentration of 27 ng/g wet, and shiner surfperch, with a median of 15 ng/g. The concentrations were lowest in leopard shark (1.6 ng/g), California halibut (3.0 ng/g), and white sturgeon (3.2 ng/g). Striped bass and jacksmelt exhibited intermediate concentrations (Figure 24; Table 2).

Controlling factors

As with other trace organic contaminants analyzed, fish tissue lipid concentration was positively related to PBDE concentration. Regression analysis indicated a significant correlation ($R^2 = 0.56$; $p < 0.0001$), indicating that fish species higher in fat content have greater muscle tissue concentrations of the PBDEs analyzed (Figure 10d). Within species, white croaker exhibited a positive relationship between sample lipid content and PBDE concentration, but other fish species did not exhibit consistent relationships (Figure 10d).

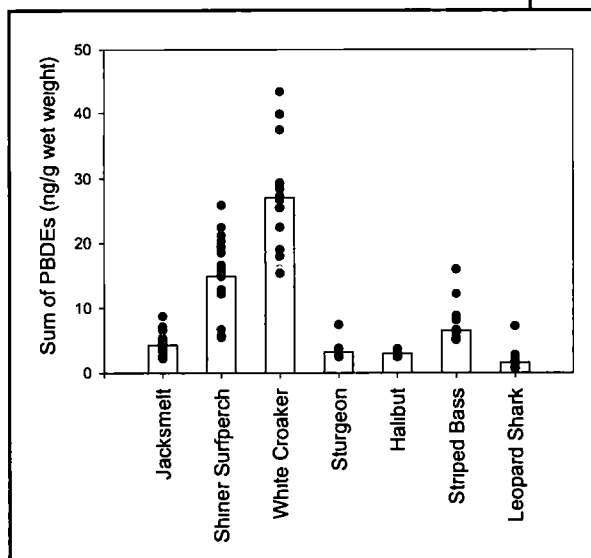


Figure 24. Estimated PBDE concentrations in Bay fish, expressed as sum of PBDEs 47, 99, and 153 (ng/g wet), summer 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. All concentrations are estimated values (refer to text).

As found in other studies, the tetrabromo diphenyl ether (BDE 47) had higher concentrations (sample median = 11.6 ng/g) than pentabromo diphenyl ether (BDE 99; median = 0.6 ng/g) or hexabromo diphenyl ether (BDE 153; median = 0.2 ng/g). Because BDE 47 tends to biomagnify more readily than the more halogenated congeners, it is typically found at relatively high concentrations in fish (Hale et al. 2001, and references therein).

Comparisons to Other Ecosystems

In order to compare concentrations to other ecosystems, median lipid weight concentrations of BDE 47 were calculated for each fish species. These values were lowest for jacksmelt and leopard shark (270 ng/g lipid and 330 ng/g lipid, respectively) and highest for white croaker and California halibut (680 and 810 ng/g lipid). The reader is reminded that the values in our study are estimated values. Furthermore, fish species varied among studies. Therefore, the following comparisons must be viewed as preliminary.

Estimated values for BDE 47 in San Francisco Estuary fish were usually higher than concentrations in fish from previous marine studies and often higher than concentrations from freshwater studies. Of the 18 marine studies summarized in Table 14 of de Wit (2002), all but one had lower average concentrations than the concentrations we report for jacksmelt. Most of the other studies were at the Baltic Sea and Japan. Estimated concentrations of BDE 47 in Estuary jacksmelt were similar to those reported in freshwater studies. Jacksmelt median concentrations were higher than 7 of the 13 concentrations reported in de Wit (2002). San Francisco Estuary white croaker had median concentrations higher than 10 of the 13 reported studies. Estimated croaker concentrations were also higher than concentrations in lake trout from for U.S. Laurentian Great Lakes (Luross et al. 2002). In general, the concentrations we report are higher than reported fish

concentrations from marine areas and relatively unpopulated freshwater areas and lower than freshwater areas in proximity to textile manufacturing plants or other industrial point sources (de Wit 2002).

Dioxin and Dioxin-Like Compounds

Introduction

Dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) is one of the most potent toxic chemicals known. Exposure to toxic concentrations of dioxin causes a variety of responses in animals, including developmental abnormalities, embryo mortality, disruption of the endocrine system, impairment of the immune system, and cancer promotion (Ahlborg et al. 1994; Van den Berg et al. 1998).

Certain other chlorinated organic contaminants are structurally similar to dioxin and consequently elicit similar toxic responses. These are referred to here as "dioxin-like compounds." Dioxin is a member of a large family of compounds known collectively as dibenzodioxins, which consist of 75 chemicals (or congeners) with different numbers and arrangements of chlorine atoms. Six of the other dibenzodioxin congeners have dioxin-like potency (Safe 1990). Chlorinated dibenzofurans are another family of compounds closely related to dibenzodioxins. Of 135 possible chlorinated dibenzofuran congeners, 10 have dioxin-like potency (Safe 1990). As mentioned earlier, some PCB congeners also have dioxin-like potency. PCBs 77, 126, and 169 are the most potent, but 9 other congeners also possess some dioxin-like potency and, due to their high concentrations in environmental samples, are significant (Ahlborg et al. 1994; Van den Berg et al. 1998).

Dibenzodioxins and dibenzofurans are formed as byproducts in combustion or manufacturing processes. The sources of dibenzodioxins and dibenzofurans in the Bay Area are mobile sources (cars, trucks, etc.), residential wood combustion, historically deposited residues in the environment, sewage treatment plants, and industrial discharges (Gervason and Tang 1998). Dibenzodioxins and dibenzofurans released to the atmosphere can deposit on land surfaces in the watershed and be transported to the Bay in storm runoff, or can deposit directly on the Bay surface. In contrast, as described earlier, PCBs, including the congeners with dioxin-like potency, were intentionally manufactured for a wide variety of applications, and have different sources and a different distribution in the watershed.

Dioxin-like compounds have a common mechanism of action based on binding to a specific cellular receptor. Given this common mechanism of action, it is possible to express the combined potency of complex mixtures of dibenzodioxins, dibenzofurans, PCBs, and other compounds as toxic equivalents (TEQs). In this approach, the relative toxicity of a dioxin-like compound compared to dioxin (toxic equivalency factor, or TEF) is applied to a measured concentration of the chemical to calculate a dioxin TEQ. For example, PCB 126 is one-tenth as potent as dioxin and has a TEF of 0.1. If a sample contains 50 pg/g wet of PCB 126, the dioxin TEQ attributable to PCB 126 in that sample is 5 pg/g wet. Dioxin TEQs for measured dioxin-like compounds with established TEFs can be added to calculate the total dioxin TEQs in a sample. TEQs can be estimated for different groups of dioxin-like compounds. The groups considered in this report and their abbreviations are defined in Table 5.

Like PCBs, dibenzodioxins and dibenzofurans are resistant to metabolism and have a high affinity for lipid. In aquatic environments dibenzodioxins, dibenzofurans, and PCBs reach higher concentrations with increasing trophic level. Consequently, predatory fish, birds, and mammals (including humans that consume fish) at the top of the aquatic food web are particularly vulnerable to the effects of contamination due to dioxin-like compounds.

A key to all of the abbreviations used in this section is provided in Table 5.

Analytical considerations

Concentrations of many of the dioxin-like compounds analyzed were usually below limits of detection, and this affected the overall precision of the dataset. Frequencies of detection for the dibenzodioxins, dibenzofurans, and PCBs 77, 126, and 169 varied between the 2000 data and prior datasets (Table 6). Frequencies of detection for three of the four compounds that contribute most to TEQs (2,3,7,8-TCDD, 1,2,3,7,8-PCDD, and 2,3,4,7,8-PCDF) were reduced compared to 1997. This likely results from the greater number of analyses of striped bass samples, which are relatively low in dioxins. Frequency of detection and quantitation was generally improved for the least abundant compounds, reflecting lower detection limits than prior years. Of the 34 samples and three duplicates submitted for analysis, two samples and one duplicate (C005504, C005102, and Q000023) provided unusable results due to matrix interference and poor chromatographic separation. Thus 32 of 34 samples were used in our presentation of results.

Although we present individual compound concentrations in Appendix Table 2e, the majority of values are estimates, designated by an "e" adjacent to the sample value. The lab reported these samples as estimates either because the sample value was below the quantification limit or because matrix interference was present. The quantification limit is defined as 10 times the standard deviation of the reported background noise in the blanks. Matrix interferences, when present, were observed in the quantitation ion or the confirmation ion. For the less toxic or less abundant dioxin-like compounds, a significant number of values were very close to the detection limits, having measured concentrations less than three times the concentrations in the blanks. These values are designated by a "B" next of the sample value, indicating the potential for low precision or blank contamination (Appendix Table 2e). Precision and accuracy were generally adequate for all compounds exhibiting detectable residues (Appendix Table 1d). An exception was 1,2,3,4,6,7,8,9 OCDD, which exhibited blank contamination, poor accuracy, and poor precision. We also present results from 3 lab duplicate analyses in Appendix Table 2e, for readers who would like to see analytical precision raw data. Note that these lab duplicates were not used in characterizing median dioxin concentrations.

Of the most toxic or most abundant dioxin-like compounds (i.e., those that contributed most to the TEQs; shown in Figure 26), qualifiers were relatively rare for 2,3,7,8-TCDF and 2,3,4,7,8-PCDF. These two furans, in addition to 1,2,3,7,8-PCDD, generally had measured values 10 times or greater the blank values (Appendix Table 1d). This fact combined with high quality of duplicate analyses and standard reference material results indicates that their measured values are reasonably accurate. Median 2,3,7,8-TCDD concentrations were close to blank concentrations (Appendix Table 1d), which, combined with the high frequency of estimated values, suggests caution in interpreting the concentration of this compound. For 1,2,3,7,8-PCDD, the majority of samples are estimated values due to matrix interferences, indicating that the value presented reflect the upper limit of the concentration that could be in the sample. In short, due to the extreme difficulty in analyzing dioxin-like compounds at pg/g concentrations, the results in this section and our interpretations should be considered best available estimates, rather than precise indicators of contaminant concentrations in Bay sport fish.

Concentrations of dioxin-like compounds in the striped bass and jacksmelt samples were approaching the limits of detection. In this situation, the handling of results reported as below detection limits (ND) can strongly influence the magnitude of calculated TEQs. The three commonly used alternatives for handling ND values in environmental samples are to substitute 1) the detection limit, 2) half the detection limit (the method used in this report), or 3) zero. These different methods would lead to median values of 0.25, 0.22, and 0.16 pg/g TEQ, respectively, in the striped bass samples, and values of 0.27, 0.20, and 0.13 in the jacksmelt sample. For white croaker and shiner surfperch, handling of ND values had an insignificant effect (causing variation of approximately

1%) on the TEQs because the most important compounds were usually detected. Unless otherwise noted, TEQ data in this report were calculated using ND values set to half the limit of detection.

Table 5. Abbreviations used in reference to dioxin-like compounds.

TCDD	tetrachlorodibenzodioxins
PCDD	pentachlorodibenzodioxins
HxCDD	hexachlorodibenzodioxins
HpCDD	heptachlorodibenzodioxins
OCDD	octachlorodibenzodioxins
TCDF	tetrachlorodibenzofurans
PCDF	pentachlorodibenzofurans
HxCDF	hexachlorodibenzofurans
HpCDF	heptachlorodibenzofurans
OCDF	octachlorodibenzofurans
TEQ	dioxin toxic equivalent due to dibenzodioxins and dibenzofurans (generic term)
TEF	dioxin toxic equivalency factor (used to calculate TEQs)
TEQ-WHO	dioxin toxic equivalent established by WHO (Van den Berg et al 1998)
ITEQs	International dioxin toxic equivalent (Ahlborg et al 1994) used in previous RMP and BPTCP reports (Faurey et al 1997; Davis et al 1999b)
PCB TEQs	dioxin toxic equivalents due to all measured dioxin-like PCBs (77, 105, 114, 118, 126, 156, 157, 169, and 189)
PCB TEQs (3 PCBs)	dioxin toxic equivalents due to PCBs 77, 126, and 169
Total TEQs	dioxin toxic equivalents due to dibenzodioxins, dibenzofurans, and all measured dioxin-like PCBs

Table 6. Frequencies of detection and quantitation for the benzodioxins, dibenzofurans, and PCBs 77, 126, and 169 in the RMP fish sampling years. TEF values from Van den Berg et al. (1998).

TEF	Analyte	Frequency of Detection (%)			Frequency of Quantitation (%)		
		1994	1997	2000	1994	1997	2000
1	2,3,7,8-TCDD	53	80	63	5	50	39
1	1,2,3,7,8-PCDD	0	80	66	0	70	51
0.1	1,2,3,4,7,8-HxCDD	11	0	32	0	0	0
0.1	1,2,3,6,7,8-HxCDD	16	70	51	0	0	32
0.1	1,2,3,7,8,9-HxCDD	0	0	22	0	0	2
0.01	1,2,3,4,6,7,8-HpCDD	11	50	59	0	0	12
0.0001	1,2,3,4,6,7,8,9-OCDD	53	70	93	26	20	49
0.1	2,3,7,8-TCDF	84	100	93	63	100	83
0.05	1,2,3,7,8-PCDF	58	70	66	11	60	49
0.5	2,3,4,7,8-PCDF	53	100	78	21	80	73
0.1	1,2,3,4,7,8-HxCDF	89	10	27	53	0	2
0.1	1,2,3,6,7,8-HxCDF	58	0	24	42	0	2
0.1	1,2,3,7,8,9-HxCDF	0	0	10	0	0	0
0.1	2,3,4,6,7,8-HxCDF	5	0	22	0	0	2
0.01	1,2,3,4,6,7,8-HpCDF	63	0	27	42	0	10
0.01	1,2,3,4,7,8,9-HpCDF	42	0	10	16	0	0
0.0001	1,2,3,4,6,7,8,9-OCDF	47	0	20	26	0	7
0.0001	PCB-77	100	100	93	100	100	93
0.1	PCB-126	100	100	93	100	100	93
0.01	PCB-169	68	100	73	58	100	71

This report employs two methods of calculating TEQs. For evaluation of current status, this report uses the human exposure TEFs for dioxins and dioxin-like compounds that were adopted by the World Health Organization (WHO) in 1998 (Van den Berg et al. 1998), identifying the resulting TEQs as "TEQ-WHO." Note that all abbreviations used in this section are presented in Table 5. In order to consistently compare present dioxin toxic equivalents with prior toxic equivalents, we also calculated them using the International Toxic Equivalents (ITEQ) method of Ahlborg et al. (1994) (Table 5). We used the ITEQ method in all of the among-year comparisons. Current status, spatial comparisons, and screening value comparisons were conducted using the TEQ-WHO method (Van den Berg et al. 1998). The most significant difference in the new TEFs, which causes an increase compared to corresponding values used in previous reports (Ahlborg et al. 1994; Fairey et al. 1997; Davis et al. 1999b), is an increase in TEF for 1,2,3,7,8 PCDD from 0.5 to 1. Note that in line with the recommendations of OEHHA (Brodberg and Pollock 1999), we also used a higher screening value (0.3 pg/g) than was used in the prior report

PCBs 77, 126, and 169 were measured in the same samples analyzed for dibenzodioxins and dibenzofurans. Dioxin toxic equivalents due to these three PCBs are reported as "PCB TEQs (3 PCBs)" (Table 5). PCB congeners, including most of the other dioxin-like PCBs, were measured using a different, less expensive method (electron capture detection gas chromatography, rather than GC-MS), and were consequently analyzed in more samples (a total of 72 samples) than dibenzodioxins, dibenzofurans, and PCBs 77, 126, and 169. PCBs 105, 114, 118, 156, 157, and 189 were analyzed using this method. Dioxin toxic equivalents due to all nine dioxin-like PCBs are reported as "PCB TEQs" (Table 5). For jacksmelt, the average PCB concentration of the three samples composited for dioxins analysis was used to estimate PCB TEQs. The two datasets were combined to evaluate the contribution of all measured dioxin-like PCBs to total TEQs in the 32 fish samples (Table 5).

For the dioxin-like compounds, the small sample size for certain years precluded confirmation of normal distributions within years. Therefore, comparisons among years were conducted for white croaker and jacksmelt using a nonparametric ANOVA (the Kruskal-Wallis test of Wilcoxon scores). Square root transformation successfully approximated normal distribution for fish captured in 2000. Therefore, spatial comparisons were conducted using ANOVA on square root transformed data. In order to gain an understanding of potentially significant patterns despite the small sample size of dioxins analyses, interpretations of statistical significance of spatial patterns in the dioxins data are presented without Bonferroni correction for multiple comparisons. It should be noted that none of the spatial patterns described in the dioxins section are statistically significant after Bonferroni correction.

Dioxin Toxic Equivalents (TEQ-WHO)

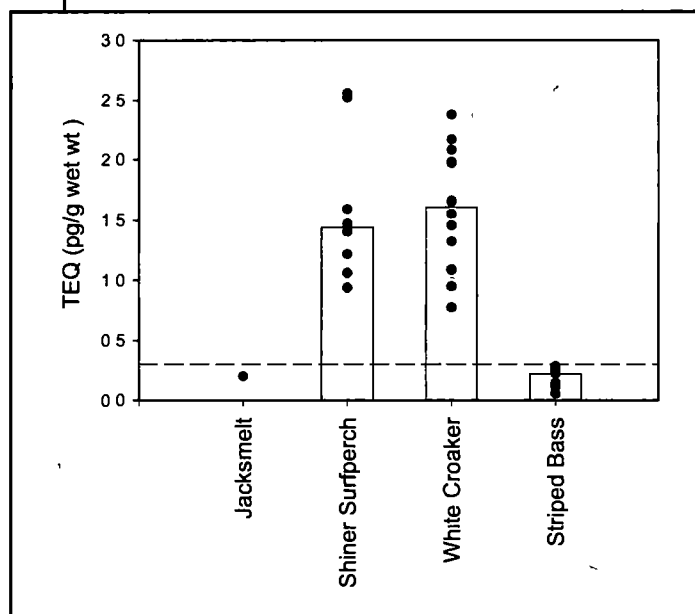
Dibenzodioxins and dibenzofurans were measured in striped bass, white croaker, shiner surfperch, and jacksmelt. White croaker and shiner surfperch exhibited the highest median TEQ-WHO, with 1.6 pg/g wet weight and 1.4 pg/g, respectively (Table 2, Figure 25). Concentrations were much lower in striped bass samples (median concentration of 0.2 pg/g) and in the single jacksmelt sample (0.2 pg/g; Figure 25). Screening value exceedances were highly species specific. All white croaker and shiner surfperch samples were above the screening value of 0.3 pg/g wet weight. In contrast, the jacksmelt sample and striped bass samples were below the screening value (Table 3).

As in 1997, four dioxin-like compounds accounted for the majority of the TEQ-WHO in the 32 fish samples (94%; Figure 26). The largest contributors to TEQ-WHO were the dibenzofurans. In particular, 2,3,4,7,8-PCDF accounted for 36% of the total TEQ-WHO, due to a combination of relatively high potency and moderately high concentrations. 2,3,7,8-TCDF accounted for an additional 22% of TEQ-WHO. In combination, dibenzodioxin congeners 2,3,7,8-TCDD and 1,2,3,7,8-PCDD accounted for 36% of TEQ-WHO.

PCB TEQS and Total TEQs

Total TEQs in the samples varied in a similar fashion as TEQ-WHO, with median concentrations higher in white croaker (6.7 pg/g wet) and shiner surfperch (6.4 pg/g wet) than in striped bass (1.2 pg/g) and jacksmelt (2.5 pg/g). The maximum total TEQ was for a shiner surfperch sample captured in Oakland (17 pg/g; Appendix Table 2e).

Figure 25. TEQ-WHO (dioxin TEQs due to dibenzodioxins and dibenzofurans) concentrations in Bay fish (pg/g wet), summer, 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Line indicates screening value (0.30 pg/g wet). TEQ-WHO are calculated using TEFs of Van den Berg et al. (1998).



The relative contributions of dibenzodioxins, dibenzofurans, and PCBs to total TEQs (Figure 27) were similar to 1997 samples, with PCBs accounting for the majority (81%) of the total TEQs. PCB 126, the most toxic dioxin-like PCB, alone accounted for an average of 49% of total TEQs. Dibenzofurans and dibenzodioxins accounted for 12% and 7%, respectively, of total TEQs. Dioxin-like PCBs accounted for most of the overall dioxin-like potency in these fish samples.

Controlling Factors

Lipophilic contaminants such as the dibenzodioxins, dibenzofurans, and PCBs accumulate in biota in propor-

tion to the amount of lipid, or fat, in their tissues. However, the strength of the lipid-contaminant relationship may vary among animal species as a function of other factors such as the dietary variation, reproductive status, spatial heterogeneity in contaminant distribution, and age (Stow et al. 1997; Lamon and Stow 1999). As observed for PCBs, chlordanes, DDTs, and PBDEs (Figure 10), concentrations of dioxins were related to tissue lipid concentrations. In the present study, when we examined all species, percent lipids was significantly positively correlated to TEQ-WHO ($R^2 = 0.34$; $p < 0.0005$; $N = 31$) (Figure 28), indicating a positive relationship with individual dioxin-like compounds. Percent lipids were also significantly positively related to 2,3,7,8-TCDF (linear regression of log transformed data; $R^2 = 0.45$; $p < 0.0001$; $N = 31$), the dioxin-like compound found at the highest, and therefore most analytically precise, concentrations in Bay samples (Figure 29). However, the strength of the lipid versus TEQ-WHO relationship varied among species. White croaker exhibited a positive relationship ($R^2 = 0.44$; $p < 0.02$; $N = 14$) but there was no significant relationship for striped bass ($p = 0.88$; $N = 8$). For shiner surfperch, the relationship was negative ($R^2 = 0.76$; $p = 0.005$; $N = 8$; Figure 28), which may result from the fact that the fish captured at Oakland Harbor, which often exhibit elevated concentrations of contaminants (Hunt et al. 1998; Davis et al. 2002; this study), had relatively low lipid content and high tissue dioxin TEQs. We hypothesize that species with extremely small home ranges (shiner surfperch; Greenfield et al. In Review) or low tissue lipid content (striped bass) exhibit weak correlations between dioxin TEQs and lipid content. For these species, spatial heterogeneity in sediment and water contaminant concentrations or individual fish variability in diet and growth rate may obscure the TEQ versus lipid correlation.

Spatial Patterns

The capture of multiple samples at multiple sites allowed us to evaluate spatial pattern in dioxins for striped bass, shiner surfperch, and white croaker. Although only two samples were analyzed at each of four sites, shiner surfperch did exhibit statistically significant spatial heterogeneity in TEQ-WHO (ANOVA of square root transformed data; $R^2 = 0.91$; $p = 0.015$). For shiner surfperch, Oakland Harbor (mean = 2.5 pg/g) exhibited significantly higher concentrations than San Francisco Waterfront or Berkeley (1.1 and 1.2 pg/g; Figure 30). As observed with other contaminants, striped bass exhibited no evidence of spatial heterogeneity among the three sites sampled ($p > 0.50$; Figure 30).

Temporal Trends

When multiple species data were compared between 1994, 1997, and 2000, there was no clear indication of an upward or downward trend (Figure 31, 32). For shiner surfperch, wet weight ITEQs were higher in 2000 than in 1994 (mean of 1.4 versus 0.9 pg/g) but this pattern was only marginally significant ($p = 0.04$), probably owing to the fact that only three fish were sampled in 1994. Lipid weight concentrations did not vary between 1994 and 2000 for surfperch. For white croaker, wet weight concentrations were not significantly different among three years but lipid weight concentrations were significantly lower in 1997 (24 pg/g lipid) than in the other two years (33 and 40 pg/g lipid; $p < 0.01$). Thus the previously observed decrease in lipid weight concentrations in 1997 croaker (Davis et al. 1999b) was offset by an increase in 2000. Striped bass exhibited an apparent decrease in wet weight concentrations, but this is an artifact of the considerably reduced detection limits in 2000 than in previous years. Because detection limit values affect estimated concentrations of non-detect samples, the reduction in detection limits in 2000 strongly reduces estimated ITEQ for striped bass, which exhibited frequent measured values below detection limits (Appendix Table 2e). In summary, measured concentrations of ITEQ exhibited some temporal variation, but analytical uncertainty, inconsistency of findings among species, differences in trends between wet versus lipid weight concentrations, and the existence of data from only three sampling periods hinder definitive conclusions about temporal trends in dioxin-like compounds in the Bay.

Selenium

Introduction

Selenium is a trace element that accumulates to concentrations of ecological concern in the Bay food web (Davis et al. 1991). The primary sources of selenium are runoff from areas with seleniferous soils and agricultural drainage from such areas, oil refinery wastewater discharges, and sewage treatment plants (Luoma and Presser 2000). Selenium is on the 303d list for several

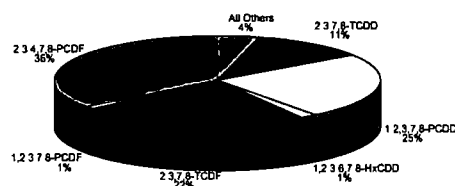


Figure 26. Contributions of dibenzodioxin and dibenzofuran congeners to TEQ-WHO (mean percentages from fish samples presented in Figure 25).

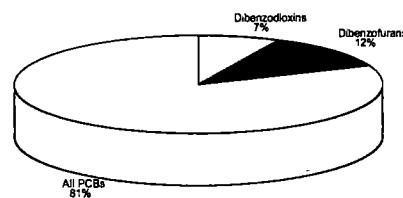


Figure 27. Contributions to total TEQs from dibenzodioxins, dibenzofurans, and dioxin-like PCBs in fish samples analyzed for both dioxin-like compounds and PCB congeners. Dioxin-like PCBs measured include PCBs 77, 105, 114, 118, 126, 156, 157, 169, and 189.

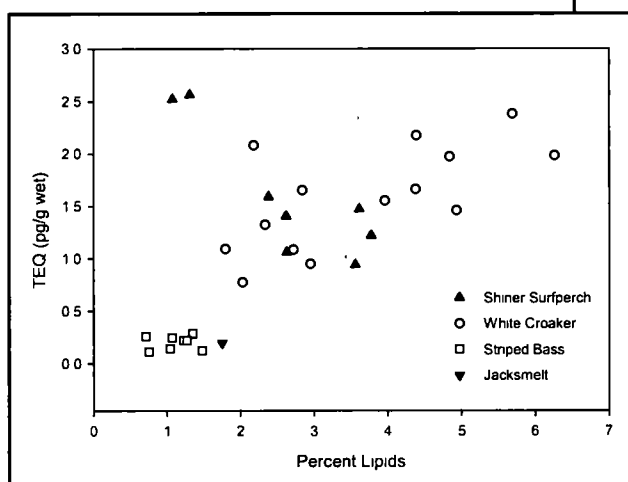
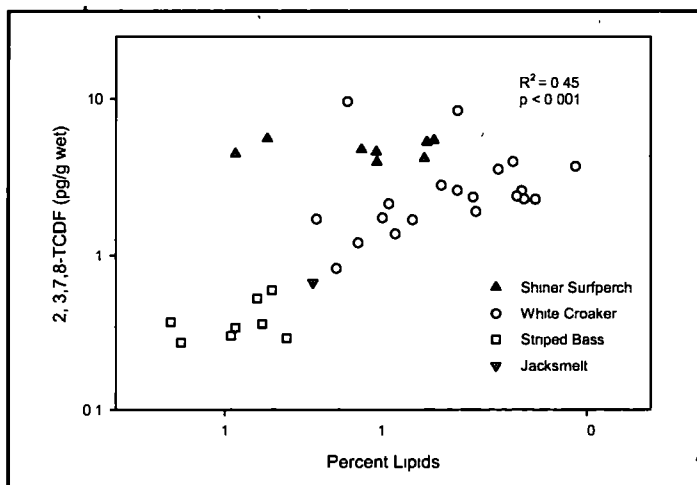


Figure 28. Correlation of TEQ-WHO (pg/g wet) with lipid in fish samples, 2000. Fish species presented include white croaker (circles), shiner surfperch (filled triangles), striped bass (squares), and jacksmelt (upside down triangle).

Figure 29. Correlation of 2,3,7,8 TCDF (pg/g wet) with lipid in fish samples, 2000. Fish species presented as Figure 29. Note log scale.



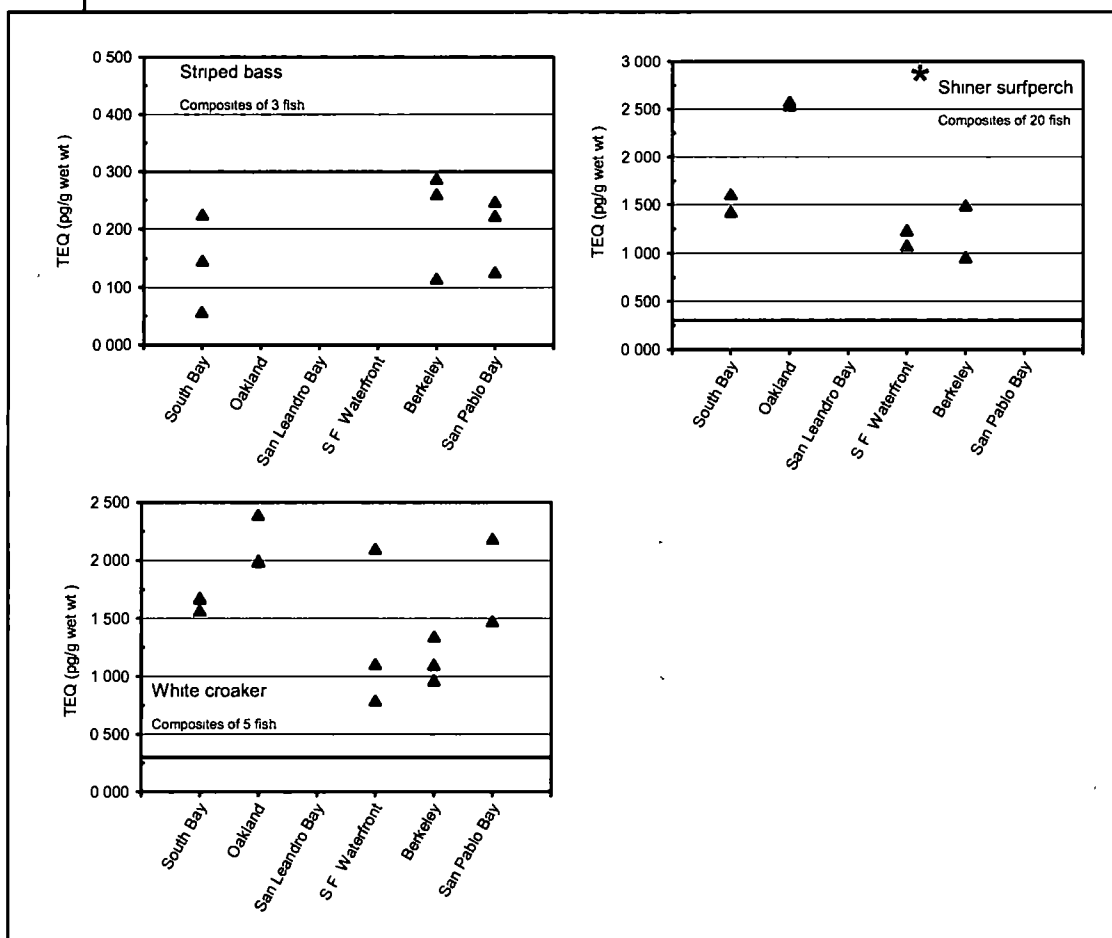
embayments of the Estuary (SFBRWQCB 2001) as a result of a consumption advisory for diving ducks. Ducks that prey on clams (surf scoter) tend to be particularly high in selenium (Urquhart and Regalado 1991).

Analytical Considerations

The RMP monitors selenium concentrations in white sturgeon because this species tends to accumulate high tissue concentrations of selenium and because sturgeon were continuously

monitored in the Selenium Verification Study from 1986 to 1990 (White et al. 1987, 1988, 1989; Urquhart and Regalado 1991). The Selenium Verification Study monitored the same fish species in similar locations (San Pablo Bay and Suisun Bay) as the RMP. Their reports document rigorous quality control with high accuracy (averaging $\leq 6\%$ RSD) and precision (average RSD of 6.8%), indicating that comparisons to the RMP data set would be appropriate (White et al. 1987; Urquhart and Regalado 1991). A small amount of sturgeon data also exists from the Toxic Substances Monitoring Program, collected in

Figure 30. Dioxin-equivalent concentrations in each sampling location, expressed as TEQ-WHO (pg/g wet), summer, 2000. Triangles are concentrations in each composite sample analyzed. Asterisk (*) indicates significance of analysis of variance at $p < 0.05$. Horizontal line indicates screening value (0.30 pg/g). Note differences in scale.



1992 and 1993. In 2000, the RMP analyzed 12 sturgeon samples for selenium. Each sample consisted of a skin-off fillet from an individual fish (Appendix 2f).

For this report, the selenium screening value was reduced from 11.7 $\mu\text{g/g}$ (used in the 1994 and 1997 reports) to 2.0 $\mu\text{g/g}$ wet weight. This six-fold reduction in screening value is based on OEHHA guidance from Robert Brodberg (*personal communication*). The two $\mu\text{g/g}$ screening value is based on human toxicity information, and accounts for the fact that humans consume additional selenium in other dietary items (Fan et al. 1988).

Results

Two of the 12 white sturgeon samples monitored in 2000, both captured in San Pablo Bay, exceeded the screening value. The highest concentration was 3.2 $\mu\text{g/g}$ wet and the median concentration was 1.4 $\mu\text{g/g}$ wet (Table 7, Appendix Table 2f). The two locations sampled, South Bay and San Pablo Bay, both had median concentrations of 1.37 $\mu\text{g/g}$ wet. Although selenium was not one of the contaminants that led to development of OEHHA's interim fish advisory, the occasional exceedance of the present screening value may be a cause for concern in sturgeon. The 1994 BPTCP study found higher concentrations in sturgeon than other species, suggesting less cause for concern for other RMP monitored fish species (Faurey et al. 1997).

When sturgeon selenium concentrations are compared from 1986 through 2000, there is no evidence of a consistent upward or downward trend (Figure 33). Median concentrations were similar in all years with the exception of 1990. Most years exhibit exceedances of the 2.0 $\mu\text{mg/g}$ screening value. The unusually high concentrations in 1990 (median wet weight concentration equaling 3.6 $\mu\text{mg/g}$) were observed to be significantly different from previous years in the Selenium Verification Study (Urquhart and Regalado 1991).

It is unclear why concentrations were elevated in 1990 as compared to other years. Several local scientists have hypothesized that the invasion of *Potamocorbula amurensis* bivalves into the Estuary is causing increased sturgeon selenium concentrations. Bivalves are a major dietary component of North Bay sturgeon and this

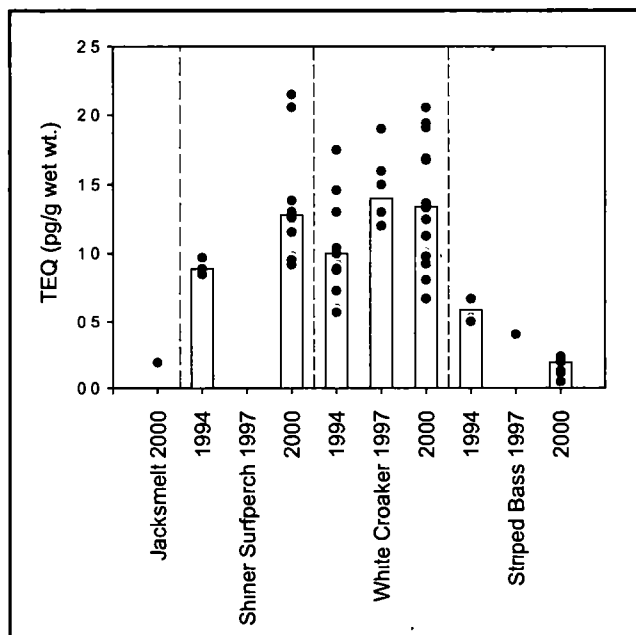


Figure 31. ITEQ concentrations in Bay fish (pg/g wet) in 1994, 1997 and 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. For consistency among years, ITEQs are calculated using the TEFs of Ahborg et al. (1994).

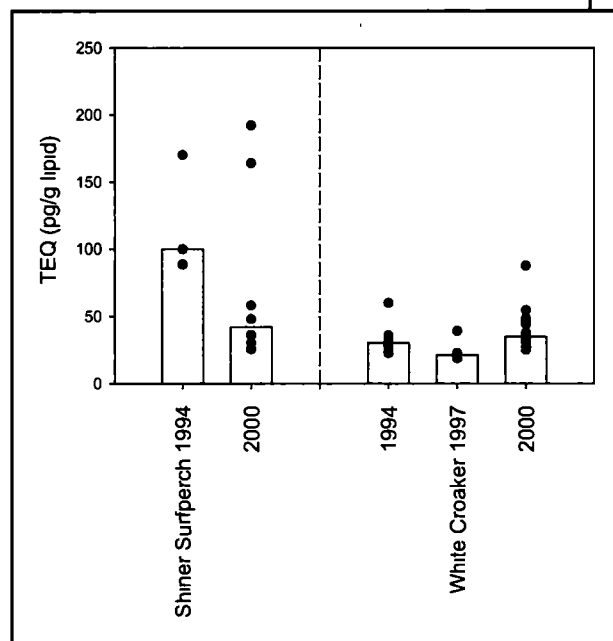


Figure 32. Lipid weight ITEQ concentrations in shiner surfperch and white croaker (pg/g lipid) in 1994, 1997 and 2000. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations.

species exhibits significantly higher concentrations than local bivalve species (Urquhart and Regalado 1991; Luoma and Presser 2000). The 1990 increase in sturgeon selenium concentrations has been hypothesized to result from increased dietary reliance on *Potamocorbula*, but the TSMP and RMP data indicate that concentrations have not remained as high as they were in 1990. Selenium loads from local oil refineries in the Bay Delta were considerably lower in 1999 than 1986-1992, due to stricter regulation on local discharge (Luoma and Presser 2000). It is possible that this reduction in loading has caused reduced bioavailability since the 1990 peak. Another major source of selenium is agricultural runoff; future management of the San Joaquin River and watershed could significantly impact loading of selenium to the San Francisco Estuary (Luoma and Presser 2000). Increased loading would likely lead to increased screening value exceedances for selenium.

Contamination in Crabs and Clams

Introduction

Crab and clam sampling were performed to help determine whether consumption of Bay-caught shellfish is a significant human health concern. To this end, species commonly captured for human consumption (Japanese littleneck clams, *Tapes japonica*, and red rock crabs, *Cancer productus*) were sampled. These species were captured at locations where recent crabbing and clamming are known to occur (Figure 2). In addition to the contaminants monitored in fish, crabs and clams were sampled for a number of heavy metals due to their potentially high bioaccumulation rates (e.g., Brown and Luoma 1995). Additionally, due to their relatively low rates of PAH elimination (reviewed in Meador et al. 1994), clams were analyzed for PAHs.

Clams

Contaminant concentrations in clams were generally similar to or below the lowest fish contaminant concentrations (Table 2). None of the clam samples exhibited screening value exceedances for mercury, DDTs, chlordanes, dieldrin, selenium, cadmium, or PAHs (Table 3, Table 7, Appendix 2) (Brodberg and Pollock 1999). For PAHs, the screening value comparison was calculated using benzo[a]pyrene equivalents, following U.S. EPA recommendations. Using this method, the "benzo[a]pyrene equivalent" concentration at the more contaminated site (0.3 ng/g) was 15 fold less than the screening value for recreational consumption of sport fish (5.47 ng/g wet; U.S. EPA 2000). Although inorganic arsenic was not measured in clams, total arsenic did exceed the screening value of 1 µg/g recommended by Brodberg and Pollock (1999), indicating the potential for concern due to consumption of this metal (Table 7, Appendix Table 2g). With the exception of total arsenic, the current available data suggest that human exposure to contaminants from bivalve consumption would be considerably less than that from consumption of

Table 7. Concentrations of selenium, arsenic, cadmium, and PAH in white sturgeon, clams, and crabs. Medians are presented for crabs and sturgeon. Because there are only two composite clam samples, means are presented for clams. PAHs are presented as both sum total of all non-alkylated PAHs and as benzo(a)pyrene (B(a)p) equivalents (calculated as recommended in U.S. EPA 2000).

	Number of Samples Analysed	Selenium (µg/g)	Total Arsenic (µg/g)	Inorganic Arsenic (µg/g)	Cadmium (µg/g)	PAH (ng/g)	PAH B(a)p equivalents (µg/g)
Screening Value		2	1	0.028	1		5.47
White Sturgeon	12	1.37	NA	NA	NA	NA	NA
Crab Muscle	6	0.81	3.00	ND	0.02	NA	NA
Crab Hepatopancreas	3	1.23	2.60	0.029	7.16	NA	NA
Clams *	2	0.93	2.24	NA	0.24	106**	0.15

NA = not analysed

ND = not detected

* mean values of two samples

** one sample was ND and value was set at 5 ng/g (1/2 of detection limit)

similar amounts of fish caught in the Estuary. More spatially extensive sampling covering a wider range of bivalve species would be required to confirm this interpretation.

Among the clam sites sampled, mercury and selenium were higher in the South Bay-Burlingame site while trace organics were higher in the Oakland-Fruitvale Bridge site. The Burlingame sample had concentrations of mercury (0.11 $\mu\text{g/g}$) and selenium (1.3 $\mu\text{g/g}$) that were twice as high as the concentrations in the Oakland sample (0.05 and 0.6 $\mu\text{g/g}$). Burlingame clam concentrations of DDTs, PAHs, chlordanes, and dieldrin were all below detection limits, and PCB concentrations were only 5.1 ng/g. In contrast, the Oakland sample had detectable residues of DDTs (4.2 ng/g) and PAHs (206 ng/g), and PCB concentrations were 21 ng/g. Although clam PCBs were only measured as total congeners, the concentration at Oakland was above the total Aroclor screening value.

Although only two clam samples were collected and sampling locations were different from fish sampling, the generally low concentrations are consistent with the hypothesis that these clams accumulate fewer contaminants than the fish. The short lifespan and relatively low trophic position of Japanese littleneck clams may cause low contaminant concentrations (as compared to fish).

Crabs

Contaminant concentrations differed greatly between crab muscle samples and crab hepatopancreas samples. For trace organic contaminants, crab muscle had lower concentrations than any of the fish sampled (Table 2). Median concentrations of selenium (0.8 $\mu\text{g/g}$), inorganic arsenic (not detected; estimated detection limit = 0.002 $\mu\text{g/g}$) and cadmium (0.018 $\mu\text{g/g}$) in muscle tissue (Appendix Table 2g) were also well below screening values (Table 7). The median value for DDTs, chlordanes, dieldrin, and most dioxins were all below detection limits in muscle tissue. Median mercury concentrations were moderately high (0.14 $\mu\text{g/g}$) and were greater than median concentrations in jacksmelt, shiner surfperch, and Japanese littleneck clams (Table 2).

In contrast to muscle tissue, crab hepatopancreas tissue was high in trace organic contaminants, possibly related to the high percent lipid in this tissue (4.3 %). For example, concentrations of DDTs (64 ng/g) and dioxin TEQ-WHO (11 pg/g) were higher in hepatopancreas than the median concentrations for any fish species (Table 2). PCB concentrations were also elevated (median 109 ng/g; congener basis). PCBs and also TEQ WHO exceeded the screening value (Table 2). Cadmium concentrations (7.16 $\mu\text{g/g}$) exceeded the 1 $\mu\text{g/g}$ screening value (Table 7). Inorganic arsenic concentrations (median concentration 0.029 $\mu\text{g/g}$) exceeded the U.S. EPA (2000) screening value of 0.028 $\mu\text{g/g}$ in two of three hepatopancreas samples (Table 7).

The very high concentrations of most contaminants in crab hepatopancreas tissue suggest that people can reduce their dietary exposure to these contaminants by preparing and eating crabs using methods that avoid consumption of the hepatopancreas. In contrast, the low to moderate contaminant concentrations in crab muscle tissue may

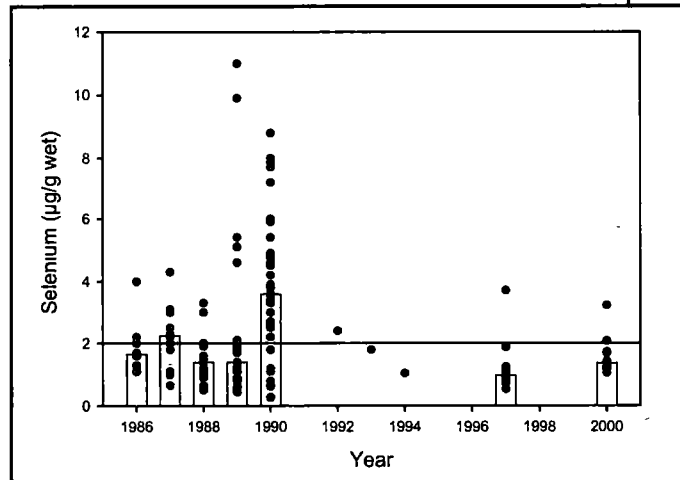


Figure 33. Long-term patterns in white sturgeon selenium concentrations. Horizontal line represents screening value (2 $\mu\text{g/g}$ wet). Gray bars represent median concentrations. Data were obtained from the Selenium Verification Study (1986 through 1990), the Toxic Substances Monitoring Program (1986 through 1993) and the Regional Monitoring Program (1994 through 2000).

indicate that, like Japanese littleneck clams, red rock crabs have relatively low contaminant burdens compared to a variety of sport fish.

Statistical evaluation of spatial pattern in crab contamination is hampered by the very low sample size (two muscle tissue samples at each of three sites). At this time, visual examination of the data set suggests the hypothesis that concentrations of some contaminants in crabs captured off the Sausalito coast may be lower than for crabs collected off the San Francisco Waterfront (Appendix 2 Tables). One of the composite muscle samples collected at Fort Baker (Sausalito coast) had the lowest concentration among all six samples for mercury, selenium, and total PCBs. Additionally, total DDTs were not detected at Fort Baker but they were above detection limits at Municipal Pier (San Francisco Waterfront). As with clams, more extensive spatial sampling would be required to test the hypothesis that contaminant exposure varies among sites.

Summary and General Discussion

Comparisons to screening values

As found in the 1994 and 1997 studies (SFBRWQCB et al. 1995; Fairey et al. 1997; Davis et al. 1999b; 2002), persistent toxic chemicals in Bay fish were found at concentrations of potential human health concern in 2000 RMP sampling. With the exception of chlordanes, every contaminant sampled in finfish in 2000 exhibited some screening value exceedances (Table 3).

PCB concentrations exceeded the screening value in almost every fish sampled (72 of 80 fish samples), including every sample of striped bass, shiner surfperch and white croaker. Dioxin TEQ-WHO exceeded the screening value in 22 of 32 fish samples, including all white croaker and shiner surfperch. Fewer samples exceeded screening values for dieldrin (15 of 80 samples) and DDTs (3 of 80 samples). All samples were below the chlordane screening value, suggesting that chlordane concentrations in fish may not pose a significant human health concern. Mercury exceeded the screening value in 51 of 134 samples, including all leopard shark samples. The selenium screening value was set at a more protective level for this report than previous reports, resulting in 2 of 12 white sturgeon sample exceedances.

New compounds, taxa and approaches

Fish monitoring for polybrominated diphenyl ethers (PBDEs) was initiated in 2000. Estimated concentrations were significantly correlated to lipid content (Figure 10d), resulting in similar interspecific variation as observed for other trace organic contaminants (Figure 24). In particular, estimated concentrations of the three PBDEs were highest in white croaker (median of 27 ng/g wet) and shiner surfperch (15 ng/g wet) and were lowest in leopard shark (1.6 ng/g wet). Considering the widespread use and potential toxicity of these compounds (Darnerud et al. 2001), it would be valuable to develop a screening value for future comparisons. As PBDE concentrations appear to be rapidly increasing in the Estuary, the RMP will continue monitoring PBDEs in fish in future rounds of sampling.

Dioxin monitoring in 2000 was much more extensive than in previous years, facilitating analysis of the species-specific and spatial variation in dioxin contamination. Dioxin equivalents (TEQ-WHO) were higher in white croaker (1.6 pg/g) and shiner surfperch (1.4 pg/g) than jacksmelt (0.2 pg/g) or striped bass (0.2 pg/g).

Clam and crab samples were analyzed for this study. For most contaminants, clam tissue and crab muscle tissue had lower concentrations than monitored sport fish (Table 2), indicating that consumption of these shellfish is not as significant an exposure route to humans as are monitored sport fish. In contrast to muscle tissue, crab hepatopancreas tissue had relatively high concentrations of trace organic contaminants, including total PCB congeners (109 ng/g) and dioxin TEQ-WHO (11 pg/g), and were also above screening values for inorganic arsenic.

The 2000 RMP fish contamination program also included two important biological studies: an analysis of the fish food web and a biomarker study. The food web analysis is treated in two separate reports (Roberts et al. 2002; Greenfield et al. In Review). The biomarker results have been written up in a draft report (Myers et al. 2002).

Controlling factors

As in previous years, fish length was an important predictor of contaminant concentrations. Extensive sampling of striped bass and leopard shark confirmed a highly significant length versus mercury relationship (Figure 4). The larger fish species (leopard shark, striped bass and white sturgeon) tended to accumulate more mercury and exhib-

ited more significant length versus mercury relationships than smaller fish species (Figure 5). Graphical analysis also indicated a positive relationship between length and DDTs for shiner surfperch and white croaker (Figure 17).

Tissue lipid content was a significant predictor of trace organic contaminants in fish. When all species were pooled, lipid content was significantly related to total PCBs, DDTs, chlordanes, PBDEs, and dioxin TEQs (Figure 10; Figure 28). Shiner surfperch and white croaker, the species highest in lipid content, had the highest concentrations of these contaminants (Table 2). For white croaker, lipid content explained variation in trace organic contaminant concentrations over time, both on a seasonal and interannual basis. Among seasons, croaker captured in the spring of 2000 had significantly lower lipids, and were lower in PCBs and chlordanes (Figure 12). Among years, 1997 croaker were higher in both DDTs and percent lipids, as compared to 1994 and 2000 (Figure 17d).

We had previously hypothesized that contaminant concentration is influenced by trophic position of Bay fish (Davis et al. 2002). Surprisingly, trophic position, as estimated from stable nitrogen isotope data, was generally not a strong predictor of variation in mercury, selenium, or organochlorine contaminants in Bay fish (Greenfield et al. In Review). For example, estimated trophic position explained some variation among species in fish mercury concentrations but very little variation within individual species. Additionally, there was no evidence that DDT or PCB concentrations were significantly related to estimated trophic position. This apparent lack of effect of trophic position may be partially attributable to difficulties applying stable isotope methods to Bay fish, given the limited isotope data we had available (Greenfield et al. In Review).

Spatial patterns

As in previous years, spatial variation was apparent for mercury and PCBs for certain fish species. This remained the case despite our use of a very conservative statistical approach (Bonferroni protection for multiple comparisons with Tukey-Kramer evaluation of pairwise differences), adding much greater confidence to the statistical significance of the findings. Using this approach, significant variation in mercury concentrations among locations was observed in shiner surfperch, jacksmelt, leopard shark, and white sturgeon (Table 4). Shiner surfperch and jacksmelt also varied significantly for PCBs. In general, Oakland and South Bay Bridges were relatively high in contaminant concentrations while Berkeley and San Pablo Bay were relatively low.

Potential causes of the observed spatial variation in fish contaminant concentrations include variation in site contamination and spatial variation in fish biology. The latter cause could include a number of attributes including diet and growth rate. Nevertheless, special studies of the Bay and published literature from other ecosystems support the hypothesis that the primary cause of spatial variation in Bay fish contamination is variation in water or sediment contamination among sites. First of all, San Leandro Bay and Oakland Harbor, having elevated contaminant concentrations in fish, are also sites of historical industrial activity, and have relatively high sediment concentrations for mercury, PCBs, and organochlorine pesticides (Hunt et al. 1998; Daum et al. 2000). Additionally, the South Bay Bridges, where shiner surfperch had significantly elevated concentrations of PCBs and mercury, are also elevated in water column concentrations of these contaminants (Leatherbarrow et al. 2002). Stable isotope evaluation of fish diets did not support the competing hypothesis that variation in fish diet causes spatial variation in contamination. In sites where fish were more contaminated, stable isotope estimates of trophic position did not appear to be higher (Greenfield et al. In Review). Many studies of other ecosystems also indicate that spatial variation in fish contamination results from variation in overall site contamination. This has been observed for trace organic contaminants (Saiki and Schmitt 1986; Madenjian et al. 1998; Kennish and Ruppel 1998; Zlokovitz and Secor 1999) and mercury (Greenfield et al. 2001).

Temporal trends

This report presents results from a seasonal examination of white croaker contamination, fish monitoring data for three sampling years, and longer-term data sets from other sampling programs. To date, it is the most complete analysis of patterns in temporal change of fish contamination in the San Francisco Estuary. In this summary we interpret these data in terms of seasonal variation, interannual fluctuation (changes among individual years that don't necessarily reflect long-term trend), and long-term trends (apparent trends over a scale of at least a decade).

Seasonal variation

Seasonal variation in trace organic contaminants in white croaker was significant and indicated that croaker sampled in the spring were less contaminated than other seasons (Figure 12). This appears to result from the lower lipid content in spring. Research on croaker in southern California indicates that they spawn in January and February, suggesting that organic contaminants are lost during spawning (Love et al. 1984). This seasonal variation should be taken into account in evaluation of human health risks from consumption of white croaker.

Interannual variation

Interannual variation was apparent for almost every contaminant monitored. Examples include elevated striped bass mercury in 1997, elevated striped bass PCBs in 1994, and elevated DDTs in both shiner surfperch and white croaker in 1997 (Figure 7; Figure 16). The interannual variation in trace organic contaminants often resulted from variation among years in fish tissue lipid content. For example, white croaker captured in 1997 had elevated lipid content, as compared to 1994 and 2000, which may explain the elevated concentrations of DDTs (Figure 17d). In other cases, interannual variation was not easily explained by fish attributes. Although striped bass had significantly higher mercury concentrations in 1997, the fish were not significantly longer than other years, indicating that mercury bioavailability may have been higher that year.

Long-term trends

Evaluation of white sturgeon and striped bass data indicated possible long-term declines in DDTs and chlordanes but no long-term trends in mercury, PCBs or selenium. The difference between these contaminants may stem from a number of factors including the date when most contaminant use was curtailed (Table 8), the rate of loading at present, and differences in environmental degradation rates.

Mercury concentration in striped bass showed no apparent trend from the early 1970s to the late 1990s (Figure 8). A major use of mercury in the region occurred over a century ago (Table 8), and consequently a significant loading reduction occurred in the early 20th-century (Nriagu 1994). Because of the widespread area and historic sources (Nriagu 1994; Domagalski 1998, 2001; Alpers and Hunerlach 2000), long-term trends in watershed loading of mercury are probably weak. Rather, fluctuation in mercury bioavailability to fish likely stems from a combination of variation in fish ecology, watershed loading (Domagalski 1998, 2001), contaminated sediment exposure (Jaffe et al. 1998; Fuller et al. 1999), and factors that influence net methylmercury production rates (e.g., Gilmour et al. 1992). Our failure to detect a trend in fish contrasts with the long-term decreases observed in sediment mercury concentrations since the mid-20th century (Hornberger et al. 1999).

Selenium loads from local oil refineries in the Bay Delta are lower in 1999 than 1986-1992, due to stricter regulation on local sources such as refinery loads (Luoma and Presser 2000). However, no effective source reduction has been implemented to reduce loading due to agricultural runoff and other nonpoint sources (Luoma and Presser 2000).

Table 8. Summary of source reduction trends in biota and sediments for contaminants that have long-term fish data. All trends are presented as from the 1970s or 1980s to the present.

Contaminant	Major restriction date	Type of restriction	Trend in fish (species) a	Trend in other studies (matrix)
Mercury	1890s	End of hydraulic gold mining activity b (though many sources still remained afterward)	None (SB)	Decline (recent sediments and bivalves) e k
Selenium	1990s c	Restriction on refinery effluent c	None (WS)	Unknown
PCBs	1979 d	Ban on new production and many uses	None (WS)	Decline (recent sediments, bivalves and shiner surfperch) f g h k
DDTs	1972 i	Ban on all uses but emergency uses	Decline (WS)	Decline (recent sediments, bivalves and shiner surfperch) f h k
Chlordanes	1987 j	Last year of widespread application in California	Decline (WS)	Decline (bivalves) k

a SB = striped bass, WS = white sturgeon. b Nriagu 1994 c Luoma and Presser 2000.
d Rice and O'Keefe 1995 e Hornberger et al 1999 f Venkatesan et al 1999 g Davis
2002. h Risebrough 1969, 1995 i U S EPA 2000 j Shigenaka 1990 k Gunther et al
1999

Hence it is not surprising that selenium concentrations in white sturgeon do not appear to have declined (Figure 33).

The contrast between declining sturgeon concentrations of chlordanes and DDTs (Figure 18; Figure 22) versus no apparent trend for PCBs (Figure 13) merits further discussion. In the case of chlordanes, the fairly recent use curtailment (1987; Table 8) may explain the decline, because organochlorine contaminant declines in wildlife tend to be strongest shortly after use bans are imposed (Schmitt and Bunck 1995; Stow et al. 1999). In contrast to chlordanes, most DDT use was curtailed in the early 1970s, but bivalves, sediments, and fish still exhibit decreasing DDT concentrations in the 1980s and early 1990s (Table 8) (Gunther et al. 1999; Venkatesan et al. 1999; this study). The fact that DDTs continue to decline may be explained by higher degradation rates for DDTs than PCBs. Alternatively, the loading rate for DDTs may be lower than for PCBs. In any event, the apparent decline of DDTs and chlordanes, combined with the low frequency or absence of screening value exceedances, suggest that they may be of lower human health concern than other contaminants.

PCBs showed no recent trend in sturgeon despite evidence of recent declines in sediments (Venkatesan et al. 2000) in addition to declining trends in bivalves since the late 1980s (Gunther et al. 1999; Davis 2002). Possible explanations for the apparent lack of PCB decline include continued loading to the watershed from local sources and slow declines in sediment due to very slow degradation rates. It is also possible that high detection limits and small sample sizes of prior programs interfered with trend detection. Determining potential input and loss rates of PCBs and other contaminants remains a major objective of the Regional Monitoring Program. Continued long-term monitoring of fish contamination will help achieve this objective by clarifying long-term trends in Bay food web contamination.

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References

- Ahlborg, U. G., G. C. Becking, L. S. Birnbaum, A. Brouwer, H. J. G. M. Derks, M. Feeley, G. Golor, A. Hanberg, J. C. Larsen, A. K. D. Liem, S. H. Safe, C. Schlatter, F. Waern, M. Younes and E. Yrjanheikki. 1994. Toxic equivalency factors for dioxin-like PCBs: Report on a WHO-ECEH and IPCS consultation, December 1993. *Chemosphere* 28(6): 1049-1067.
- Allen, J. M., P. V. Velez, D. W. Diehl, S. E. McFadden and M. Kelsh. 1996. Demographic variability in seafood consumption rates among recreational anglers of Santa Monica Bay, California, in 1991-1992. *Fishery Bulletin* 94: 597-610.
- Alpers, C. N. and M. P. Hunerlach. 2000. Mercury contamination from historic gold mining in California. Sacramento, CA, USGS: 6.
- Andersson, O. and G. Blomkvist. 1981. Polybrominated aromatic pollutants found in fish in Sweden. *Chemosphere* 10: 1051-1060.
- Brinkmann, U. A. T. and A. d. Kok. 1980. Production, properties and usage. Halogenated Biphenyls, Terphenyls, Naphthalenes, Dibenzodioxins and Related Products. Topics in Environmental Health. R. D. Kimbrough. Amsterdam, Netherlands, Elsevier/North-Holland Biomedical Press. Volume 4.
- Brodberg, R. K. and G. A. Pollock. 1999. Prevalence of selected target chemical contaminants in sport fish from two California lakes: public health designed screening study. Sacramento, CA, Office of Environmental Health Hazard Assessment: 21 pp. + Appendices.
- Brown, C. L. and S. N. Luoma. 1995. Use of the euryhaline bivalve *Potamocorbula amurensis* as a biosentinel species to assess trace metal contamination in San Francisco Bay. *Marine Ecology Progress Series* 124: 129-142.
- Brown, M. J. and B. R. Murphy. 1991. Relationship of relative weight (Wr) to proximate composition of juvenile striped bass and hybrid striped bass. *Transactions of the American Fisheries Society* 120: 509-518.
- Calhoun, A. J. 1952. Annual migrations of California striped bass. *California Fish and Game* 38(3): 391-403.
- CSWRCB. 1980. First Progress Report: Cooperative Striped Bass Study. California State Water Resources Control Board.
- Darnerud, P. O., G. S. Eriksen, T. J hannesson, P. B. Larsen and M. Viluksela. 2001. Polybrominated diphenyl ethers: occurrence, dietary exposure, and toxicology. *Environmental Health Perspectives* 109(Supplement 1): 49-68.
- Daum, T., S. Lowe, R. Toia, G. Bartow, R. Fairey, J. Anderson and J. Jones. 2000. Sediment contamination in San Leandro Bay, CA. Richmond, CA, San Francisco Estuary Institute, San Francisco Bay Regional Water Quality Control Board, California Department of Fish and Game, and Port of Oakland: 52 pp. Available from <<http://www.sfei.org/Sanleandrobay/finals1bay.pdf>>
- Davis, J. A. 1997. Concentrations and effects of organochlorine contaminants in double-crested cormorant embryos from San Francisco Bay. Davis, CA, University of California at Davis.
- Davis, J. A. 2002. The long term fate of PCBs in San Francisco Bay. Oakland, CA, SFEI.
- Davis, J. A., A. J. Gunther, J. M. O'Connor, B. J. Richardson, R. B. Spies, E. Wyatt and E. Larson. 1991. Status and Trends Report on Pollutants in the San Francisco Estuary. Oakland, CA, San Francisco Estuary Project.
- Davis, J. A., R. Hoenicke, R. W. Risebrough, W. M. Jarman, C. A. Bacon, J. Vedder and J. L. Sericano. 1997. PCB intercalibration exercise with Regional Monitoring Program water sample extracts. 1996 Annual Report: San Francisco Estuary Regional Monitoring Program. Richmond, CA, San Francisco Estuary Institute: 234-239.

- Davis, J. A., K. Abu-Saba and A. J. Gunther. 1999a. Technical report of the sources, pathways and loadings workgroup. Richmond, CA, San Francisco Estuary Institute: 46 pp. Available from <http://www.sfei.org/rmp/reports/splwg/splwg_finalv2.pdf>
- Davis, J. A., M. D. May, S. E. Wainwright, R. Fairey, C. Roberts, G. Ichikawa, R. Tjeerdema, M. Stoelting, J. Becker, M. Petreas, M. Mok, M. McKinney and K. Taberski. 1999b. Contaminant concentrations in fish from San Francisco Bay, 1997. Richmond, CA, SFEI: 65 pp. Available from <http://www.sfei.org/rmp/reports/fish_contamination/ <http://www.sfei.org/rmp/reports/fish_contamination/fish_contamination.html>
- Davis, J. A., M. D. May, B. K. Greenfield, R. Fairey, C. Roberts, G. Ichikawa, M. S. Stoelting, J. S. Becker and R. S. Tjeerdema. 2002. Contaminant concentrations in sport fish from San Francisco Bay, 1997. *Marine Pollution Bulletin*. 44: 1117-1129.
- de Wit, C. A. 2002. An overview of brominated flame retardants in the environment. *Chemosphere* 46: 583-624.
- Dearth, M. A. and R. M. Hites. 1991. Complete analysis of technical chlordane using negative ionization mass spectrometry. *Environ. Sci. Technol.* 25(2): 245-254.
- Domagalski, J. 1998. Occurrence and transport of total mercury and methyl mercury in the Sacramento River Basin, California. *Journal of Geochemical Exploration* 64: 277-291.
- Domagalski, J. 2001. Mercury and methylmercury and water and sediment of the Sacramento River Basin, California. *Applied Geochemistry* 16: 1677-1691.
- Draper, N. R. and H. Smith. 1998. *Applied Regression Analysis*. New York, Wiley-Interscience.
- Fairey, R., K. Taberski, S. Lamerdin, E. Johnson, R. P. Clark, J. W. Downing, J. Newman and M. Petreas. 1997. Organochlorines and other environmental contaminants in muscle tissues of sportfish collected from San Francisco Bay. *Marine Pollution Bulletin* 34(12): 1058-1071.
- Fan, A. M., S. A. Book, R. R. Neutra and D. M. Epstein. 1988. Selenium and human health implications in California San Joaquin Valley. *Journal of Toxicology and Environmental Health* 23: 539-559.
- Fuller, C. C., A. van Geen, M. Baskaran and R. Anima. 1999. Sediment chronology in San Francisco Bay, California, defined by 210 Pb, 234 Th, 137 Cs, and 239,240 Pu. *Marine Chemistry* 64: 7-27.
- Gervason, R. and L. Tang. 1998. Dioxin in the Bay environment. A review of the environmental concerns, regulatory history, current status, and possible regulatory options. Oakland, CA, San Francisco Regional Water Quality Control Board.
- Gilmour, C. C., E. A. Henry and R. Mitchell. 1992. Sulfate stimulation of mercury methylation in fresh-water sediments. *Environmental Science & Technology* 26(11): 2281-2287.
- Gobas, F. A. P. C., J. R. McCorquodale and G. D. Haffner. 1993. Intestinal absorption and biomagnification of organochlorines. *Environ. Toxicol. Chem.* 12: 567-576.
- Gobas, F. A. P. C. and J. Wilcockson. 2002. San Francisco PCB food-web model. Report produced for the California Regional Water Quality Control Board San Francisco Bay Region. Vancouver, BC, Simon Fraser University: 43 pp.
- Greenfield, B. K., J. A. Davis, G. Ichikawa, M. Stephenson, D. G. Slotton, S. Ayers and W. Jarman. 2001. Mercury contamination of sport fish in the Delta and its tributaries. NorCal SETAC 11th Annual Meeting, Santa Cruz, CA. Available from <<http://www.sfei.org/cmr/Mercury.pdf>>
- Greenfield, B. K., J. A. Davis, C. Roberts, R. Fairey, M. A. Sigala and J. Negrey. (In Review.) The relationship between trophic position, spatial location, and contaminant concentration for San Francisco Bay sport fish: a stable isotope study. Oakland, CA, SFEI.
- Gunther, A. J., J. A. Davis, D. D. Hardin, J. Gold, D. Bell, J. R. Crick, G. M. Scelfo,

- J. Sericano and M. Stephenson. 1999. Long-term bioaccumulation monitoring with transplanted bivalves in the San Francisco Estuary. *Marine Pollution Bulletin* 38(3): 170-181.
- Hale, R. C., M. J. La Guardia, E. P. Harvey, T. M. Mainor, W. H. Duff and M. O. Gaylor. 2001. Polybrominated diphenyl ether flame retardants in Virginia freshwater fishes (USA). *Environmental Science and Technology* 35(23): 4585-4591.
- Hornberger, M. I., S. N. Luoma, A. v. Geen, C. Fuller and R. Anima. 1999. Historical trends of metals in the sediments of San Francisco Bay, California. *Marine Chemistry* 64: 39-55.
- Howard, P. H. 1991. *Handbook of environmental degradation rates*. Chelsea, Michigan, Lewis.
- Hunt, J. W., B. S. Anderson, B. M. Phillips, J. Newman, R. S. Tjeerdema, K. Taberski, C. J. Wilson, M. Stephenson, H. M. Puckett, R. Fairey and J. Oakden. 1998. Sediment quality and biological effects in San Francisco Bay: Bay Protection and Toxic Cleanup Program Final Technical Report. Oakland, CA, San Francisco Bay Regional Water Quality Control Board.
- Jaffe, B. E., R. E. Smith and L. Z. Torresan. 1998. Sedimentation and bathymetric change in San Pablo Bay: 1856-1983. Menlo Park, CA, USGS.
- Johnson, B. and Looker, R. 2003. Mercury in San Francisco Bay. Total Maximum Daily Load (TMDL) Project Report. San Francisco Bay Regional Water Quality Control Board. 94 pp. Available from <<http://www.swrcb.ca.gov/rwqcb2/sfbaymercurytmdl.htm>>
- Kahn, E. and others. 1971. Mercury in the California environment interim report (July 1971). Berkeley, California, California State Department of Public Health: 15 pp. + Apps.
- Kennish, M. J. and B. E. Ruppel. 1998. Organochlorine contamination and selected estuarine and coastal marine finfish and shellfish of New Jersey. *Water, Air, and Soil Pollution* 101: 123-136.
- Lamon, E. C. and C. A. Stow. 1999. Sources of variability in microcontaminant data for Lake Michigan salmonids: statistical models and implications for trend detection. *Can. J. Fish. Aquat. Sci.* 56(Suppl. 1): 71-85.
- Leatherbarrow, J. and S. Lowe. 2001. Water Monitoring. Regional Monitoring Program 1999 Results. Richmond, CA, Regional Monitoring Program: 9-57. Available from <http://www.sfei.org/rmp/1999/RMP99_Results.pdf>
- Leatherbarrow, J. E., R. Hoenicke and L. J. McKee. 2002. Results of the Estuary Interface Pilot Study 1996-1999. Oakland, CA, SFEI: 94 pp.
- Love, M. S., G. E. McGowen, W. Westphal, R. J. Lavenberg and L. Martin. 1984. Aspects of the life history and fishery of the white croaker, *Genyonemus lineatus* (Sciaenidae), off California. *Fishery Bulletin* 82(1): 179-198.
- Lowe, S., R. Hoenicke, J. Davis and G. Scelfo. 1999. 1999 Quality Assurance Project Plan for the Regional Monitoring Program for Trace Substances, SFEI. Available from <http://www.sfei.org/rmp/reports/1999_QAPP/99_QAPP.html>
- Luoma, S. N. and T. S. Presser. 2000. Forecasting selenium discharges to the San Francisco Bay-Delta Estuary: ecological effects of a proposed San Luis drain extension. Menlo Park, California, USGS: 157 pp. + Figs. and Apps.
- Luross, J. M., M. Alaei, D. B. Sergeant, C. M. Cannon, D. M. Whittle, K. R. Solomon and D. C. G. Muir. 2002. Spatial distribution of polybrominated diphenyl ethers and polybrominated biphenyls in lake trout from the Laurentian Great Lakes. *Chemosphere* 46: 665-672.
- Mackay, D., W. Y. Shiu and K. C. Ma. 1992. *Illustrated Handbook of Physical-Chemical Properties and Environmental Fate For Organic Chemicals*. Chelsea, MI, Lewis Publishers.
- Madenjian, C. P., G. E. Noguchi, R. C. Haas and K. S. Schrouder. 1998. Sexual difference in polychlorinated biphenyl accumulation rates of walleye

- (*Stizostedion vitreum*). Can. J. Fish. Aquat. Sci. 55: 1085-1092.
- McFarland, V. A. and J. U. Clarke. 1989. Environmental occurrence, abundance, and potential toxicity of polychlorinated biphenyl congeners: Considerations for a congener-specific analysis. Environ. Health Perspectives 81: 225-239.
- Meador, J. P., J. E. Stein, W. L. Reichert and U. Varanasi. 1995. Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. Reviews of Environmental Contamination and Toxicology 143: 79-165.
- Minns, C. K. 1995. Allometry of home range size in lake and river fishes. Can. J. Fish. Aquat. Sci. 52(7): 1499-1508.
- MLML. 2000. Contaminant concentrations in sportfish Cruise Report Regional Monitoring Program 2000. Moss Landing, California, Moss Landing Marine Laboratories: 32 pp.
- Myers, M. S., B. F. Anulacion, J. L. Buzitis, C. Roberts, R. Fairey, and T. K. Collier. 2002. Biomarkers of chemical contaminant exposure and effects in white croaker (*Genyonemus lineatus*) from San Francisco Bay and Half Moon Bay, California; present status and historical comparisons: Draft report. Seattle, WA, Environmental Conservation Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration: 40 pp.
- Newman, J. W., J. S. Becker, G. Blondina and R. S. Tjeerdema. 1998. Quantitation of Aroclors using congener-specific results. Environ. Toxicol. Chem. 17: 2159-2167.
- Nriagu, J. O. 1994. Mercury pollution from the past mining of gold and silver in the Americas. The Science of the Total Environment 149: 167-181.
- OEHHA. 1997. Health advisory on catching and eating fish: interim sport fish advisory for San Francisco Bay, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Available from <http://www.oehha.org/fish/nor_cal/int-ha.html>
- Oros, D. R. and K. Taberski. 2002. Closing in on unidentified contaminants. Pulse of the Estuary 2000 Update: 18-19. Available from <http://www.sfei.org/rmp/2000/pulse_2000.pdf>
- Oros, D. R. and N. David. 2002. Identification and evaluation of unidentified organic contaminants in the San Francisco Estuary. Oakland, CA, SFEI: 119 pp. Available from <http://www.sfei.org/rmp/reports/unidentified_contaminants/unidentifiedcont.pdf>
- Rasmussen, D. 1993. Toxic Substances Monitoring Program 1991 data report. Division of Water Quality, California EPA: 27 pp. + Apps Available from <<http://www.swrcb.ca.gov/programs/smw>>
- Rasmussen, D. 1995. Toxic Substances Monitoring Program 1992-93 data report. Division of Water Quality, California EPA: 34 pp. + Apps. Available from <<http://www.swrcb.ca.gov/programs/smw>>
- Rasmussen, D. and H. Blethrow. 1991. Toxic Substances Monitoring Program 1988-89 Division of Water Quality, California EPA: 104 pp. + Apps.
- Rice, C. P. and P. O'Keefe. 1995. Source, pathways, and effects of PCBs, dioxins, and dibenzofurans. Handbook of Ecotoxicology. D. J. Hoffman, B. A. Rattner, G. A. Burton, Jr. and J. Cairns, Jr. Boca Raton, FL, Lewis Publishers.
- Risebrough, R. W. 1969. Chlorinated hydrocarbons in marine ecosystems. Chemical Fallout. M. W. Miller and G. G. Berg. Springfield, Illinois, Charles C. Thomas: 5-23.
- Risebrough, R. W. 1995. Polychlorinated biphenyls in the San Francisco Bay ecosystem: a preliminary report on changes over three decades. Regional Monitoring Program for Trace Substances 1995 Annual Report. SFEI. Richmond, CA, Regional Monitoring Program: 287-297. Available from <http://www.sfei.org/rmp/RMP_Annual_Reports/1995_RMP_Annual_Report.pdf>

- Roberts, C., M. A. Sigala, R. Dunn, R. Fairey and E. Landrau. 2002. Data report for the investigation of bioaccumulation of PCBs in San Francisco Bay. Oakland CA, San Francisco Regional Water Quality Control Board: 45 pp.
- Safe, S. 1990. Polychlorinated biphenyls (PCBs), dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs), and related compounds: Environmental and mechanistic considerations which support the development of toxic equivalency factors. *Crit. Rev. Toxicol.* 21(1): 51-88.
- Saiki, M. K. and C. J. Schmitt. 1986. Organochlorine chemical residues in bluegills and common carp from the irrigated San Joaquin Valley floor, California. *Archives of Environmental Contamination and Toxicology* 15: 357-366.
- SAS Institute. 1990. SAS/STAT User's Guide, Version 6, Fourth Edition. Cary, NC, SAS Institute.
- Schmitt, C. J. and C. M. Bunck. 1995. Persistent environmental contaminants in fish and wildlife. 2002. Available from <<http://biology.usgs.gov/s+t/noframe/u208.htm>>
- SFBRWQCB. 1995. Contaminant levels in fish tissue from San Francisco Bay: final report. Oakland, CA, San Francisco Regional Water Quality Control Board, State Water Resources Control Board, and California Department of Fish and Game.
- SFBRWQCB. 2001. Proposed revisions to Section 303(d) list and priorities for development of total maximum daily loads (TMDLs) for the San Francisco Bay region. Oakland, CA, San Francisco Bay Regional Water Quality Control Board: 87 pp. Available From <<http://www.swrcb.ca.gov/tmdl/docs/segments/region2/303drb22.pdf>>
- SFEI. 2000. San Francisco Bay Seafood Consumption Study. Richmond, CA. SFEI, California Department of Health Services: 84 + Apps. Available from <<http://www.sfei.org/rmp/sfcindex.htm>>
- She, J., M. Petreas, J. Winkler, P. Visita, M. McKinney and D. Kopec. 2002. PBDEs in the San Francisco Bay Area: measurements in harbor seal blubber and human breast adipose tissue. *Chemosphere* 46(5): 697-707.
- Shigenaka, G. 1990. Chlordane in the marine environment of the United States: review and results from the National Status and Trends Program. Seattle, WA, NOAA: 230 pp. + Apps.
- Sokal, R. R. and F. J. Rohlf. 1995. *Biometry: the principles and practice of statistics in biological research* New York, Freeman.
- Stehr, C. M., M. S. Myers, D. G. Burrows, M. M. Krahn, J. P. Meador, B. B. McCain and U. Varanasi. 1997. Chemical contamination and associated liver diseases in two species of fish from San Francisco Bay and Bodega Bay. *Ecotoxicology* 6(1): 35-65.
- Stow, C. A., L. J. Jackson and J. F. Amrhein. 1997. An examination of the PCB:lipid relationship among individual fish. *Can. J. Fish. Aquat. Sci.* 54: 1031-1038.
- Stow, C. A., L. J. Jackson and S. R. Carpenter. 1999. A mixed-order model to assess contaminant declines. *Environmental Monitoring and Assessment* 55: 435-444.
- Suedel, B. C., J. A. Boraczek, R. K. Peddicord, P. A. Clifford and T. M. Dillon. 1994. Trophic transfer and biomagnification potential of contaminants in aquatic ecosystems. *Reviews of Environmental Contamination and Toxicology* 136: 21-89.
- Tremblay, G., P. Legendre, J.-F. Doyon, R. Verdon and R. Schetagne. 1998. The use of polynomial regression analysis with indicator variables for interpretation of mercury in fish data. *Biogeochemistry* 40: 189-201.
- U. S. EPA. 1997. Mercury Study Report To Congress. U.S. Environmental Protection Agency. Available from <<http://www.epa.gov/oar/mercury.html>>
- U. S. EPA. 2000. Guidance for assessing chemical contaminant data for use in fish advisories. Volume 1 Fish sampling and analysis. 3rd edition. ,

- U.S. Environmental Protection Agency.
- Urquhart, K. A. F. and K. Regalado. 1991. Selenium Verification Study, 1988-1990. Sacramento, California, California State Water Resources Control Board: 94 pp. + 7 Apps.
- Van den Berg, M., L. Birnbaum, A. T. C. Bosveld and 21 others. 1998. Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife. Environmental Health Perspectives 106(12): 775-792.
- Venkatesan, M. I., R. P. de Leon, A. van Geen and S. N. Luoma. 1999. Chlorinated hydrocarbon pesticides and polychlorinated biphenyls in sediment cores from San Francisco Bay. Marine Chemistry 64: 85-97.
- White, J. R., P. S. Hoffman, D. Hammond and S. Baumgartner. 1987. Selenium Verification Study: 1986. Sacramento, California, California State Water Resources Control Board: 79 pp. + 9 Apps.
- White, J. R., P. S. Hoffman, D. Hammond and S. Baumgartner. 1988. Selenium Verification Study: 1986-1987. Sacramento, California, California State Water Resources Control Board: 60 pp. + 8 Apps.
- White, J. R., P. S. Hoffman, K. A. F. Urquhart, D. Hammond and S. Baumgartner. 1989. Selenium Verification Study: 1987-88. Sacramento, California, California State Water Resources Control Board: 81 pp. + 11 Apps.
- Wolfe, M. F., S. Schwarzbach and R. A. Sulaiman. 1998. Effects of mercury on wildlife: A comprehensive review. Environ. Toxicol. Chem. 17(2): 146-160.
- Zlokovitz, E. R. and D. H. Secor. 1999. Effect of habitat use on PCB body burden in Hudson River striped bass (*Morone saxatilis*). Can. J. Fish. Aquat. Sci. 56(Suppl. 1): 86-93.

Appendix – Data Tables

Appendix Table 1a. Quality assurance and control summary for laboratory analysis of fish tissue (trace elements)

Parameter	Number Samples	Median Field Sample	Units	MDL	Number Replicates	SD Replicates	Precision (RSD%)	Accuracy (% Error) ^a	Blank Mean
Hg (wet wt.)	117	0.25	ng/g wet	0.04	29	0.07	11	1	All ND
Se (wet wt)	12	1.37	ng/g wet	0.02	1	0.04	2	9	All ND

a Mean of absolute value of error of all standard reference material comparisons

ND = not detected

Appendix Table 1b. Quality assurance and control summary for laboratory analysis of fish tissue (PCBs).

Parameter	Totals ^a	Number Samples	Median Field Sample	Units	MDL	Number Replicates ^b	SD Replicates ^b	Precision (RSD%)	Accuracy (% Error) ^c	Blank Mean
PCB 008	PCB	80	0	ng/g wet	0.2	0	NA	NA	NA	All ND
PCB 018	PCB	80	0	ng/g wet	0.2	0	NA	NA	17	All ND
PCB 027		80	0	ng/g wet	0.2	0	NA	NA	NA	All ND
PCB 028	PCB	80	0.32	ng/g wet	0.2	4	0.03	22	19	All ND
PCB 029		80	0	ng/g wet	0.2	0	NA	NA	NA	All ND
PCB 031	PCB	80	0.24	ng/g wet	0.2	2	0.02	6	66	All ND
PCB 033	PCB	80	0	ng/g wet	0.2	1	0.02	22	NA	All ND
PCB 044	PCB	80	0.54	ng/g wet	0.2	3	0.05	10	6	All ND
PCB 049	PCB	80	0.78	ng/g wet	0.2	4	0.05	12	18	All ND
PCB 052	PCB	80	1.40	ng/g wet	0.2	4	0.06	8	6	All ND
PCB 056	PCB	80	0	ng/g wet	0.2	3	0.04	35	NA	All ND
PCB 060	PCB	80	0	ng/g wet	0.2	2	0.03	23	NA	All ND
PCB 066	PCB	80	0.86	ng/g wet	0.2	5	0.05	9	5	All ND
PCB 070	PCB	80	0.73	ng/g wet	0.2	5	0.04	17	NA	0.04
PCB 074	PCB	80	0.55	ng/g wet	0.2	5	0.02	10	NA	All ND
PCB 087	PCB	80	1.22	ng/g wet	0.2	5	0.02	8	7	All ND
PCB 095	PCB	80	1.78	ng/g wet	0.2	4	0.08	7	6	All ND
PCB 097	PCB	80	0.57	ng/g wet	0.2	4	0.04	6	NA	All ND
PCB 099	PCB	80	3.07	ng/g wet	0.2	5	0.16	8	5	All ND
PCB 101	PCB	80	4.68	ng/g wet	0.2	5	0.10	8	20	0.04
PCB 105	PCB	80	1.40	ng/g wet	0.2	5	0.12	22	7	All ND
PCB 110	PCB	80	3.11	ng/g wet	0.2	5	0.32	12	4	0.09
PCB 114		80	0	ng/g wet	0.2	0	NA	NA	NA	All ND
PCB 118	PCB	80	4.12	ng/g wet	0.2	5	0.19	8	2	0.04
PCB 128		80	1.04	ng/g wet	0.2	5	0.06	7	10	All ND
PCB 137	PCB	80	0.27	ng/g wet	0.2	5	0.03	12	NA	All ND
PCB 138	PCB	80	10.06	ng/g wet	0.2	5	0.60	8	15	All ND
PCB 141	PCB	80	0.86	ng/g wet	0.2	4	0.05	5	NA	All ND
PCB 149	PCB	80	4.02	ng/g wet	0.2	5	0.24	9	14	All ND
PCB 151	PCB	80	2.17	ng/g wet	0.2	4	0.17	7	9	All ND
PCB 153	PCB	80	14.75	ng/g wet	0.2	5	0.81	8	12	All ND
PCB 156	PCB	80	0.44	ng/g wet	0.2	5	0.02	6	9	All ND
PCB 157		80	0	ng/g wet	0.2	2	0.02	6	NA	All ND
PCB 158	PCB	80	0.82	ng/g wet	0.2	5	0.04	7	NA	All ND
PCB 170	PCB	80	1.74	ng/g wet	0.2	5	0.10	8	65	All ND
PCB 174	PCB	80	0.59	ng/g wet	0.2	4	0.07	4	NA	All ND
PCB 177	PCB	80	1.81	ng/g wet	0.2	5	0.09	9	NA	All ND
PCB 180	PCB	80	4.91	ng/g wet	0.2	5	0.34	8	28	All ND
PCB 183	PCB	80	2.17	ng/g wet	0.2	5	0.12	8	17	All ND
PCB 187	PCB	80	5.12	ng/g wet	0.2	5	0.33	8	8	All ND
PCB 189		80	0	ng/g wet	0.2	1	0.00	3	NA	All ND
PCB 194	PCB	80	0.76	ng/g wet	0.2	5	0.05	10	NA	All ND
PCB 195	PCB	80	0.31	ng/g wet	0.2	5	0.02	8	NA	All ND
PCB 200		80	0.29	ng/g wet	0.2	5	0.02	8	NA	All ND
PCB 201	PCB	80	1.11	ng/g wet	0.2	5	0.06	8	NA	All ND
PCB 203	PCB	80	0.63	ng/g wet	0.2	5	0.03	7	NA	All ND
PCB 206		80	0.32	ng/g wet	0.2	5	0.02	9	NA	All ND
PCB 209		80	0	ng/g wet	0.2	5	0.01	8	NA	All ND

a Indicates whether congeners is part of the total PCB summation Blank cells are not part of the total

b Duplicate laboratory analyses of field samples for which concentrations were above the detection limit

c Mean absolute value of error of all analyses, using NIST Standard Reference Materials 2974 and/or 2978

NA = not available

ND = not detected

Appendix Table 1c. Quality assurance and control summary for laboratory analysis of fish tissue (Pesticides).

Parameter	Totals ^a	Number Samples	Median Field Sample	Units	MDL	Number Replicates ^b	SD Replicates ^b	Precision (RSD%)	Accuracy (% Error) ^c	Blank Mean
aldnn		80	0	ng/g wet	1	0	NA	NA	NA	All ND
alpha-Chlordane	CHLOR	80	0	ng/g wet	2	5	0.08	9	17	All ND
gamma-Chlordane	CHLOR	80	0	ng/g wet	2	5	0.04	14	17	All ND
alpha-Chlordene		80	0	ng/g wet	1	1	0.01	7	NA	All ND
gamma-Chlordene		80	0	ng/g wet	1	3	0.03	16	NA	All ND
chlorpyrifos		80	0	ng/g wet	2	1	0.04	30	NA	All ND
dacthal		80	0	ng/g wet	2	1	0.02	9	NA	All ND
o,p'-DDD	DDT	80	0	ng/g wet	2	4	0.13	7	31	All ND
p,p'-DDD	DDT	80	5.39	ng/g wet	2	5	1.45	8	8	All ND
o,p'-DDE	DDT	80	0	ng/g wet	2	4	0.04	10	25	All ND
p,p'-DDE	DDT	80	25.20	ng/g wet	2	5	1.33	8	8	All ND
p,p'-DDMU		80	0	ng/g wet	3	4	0.20	8	NA	All ND
o,p'-DDT	DDT	80	0	ng/g wet	3	4	0.06	11	80	All ND
p,p'-DDT	DDT	80	0	ng/g wet	5	5	0.18	9	69	All ND
diazinon		80	0	ng/g wet	20	0	NA	NA	NA	All ND
dieldrin		80	0	ng/g wet	2	4	0.12	32	27	All ND
endosulfan I		80	0	ng/g wet	2	0	NA	NA	NA	All ND
endrin		80	0	ng/g wet	2	0	NA	NA	NA	All ND
ethion		80	0	ng/g wet	6	1	0.06	17	NA	All ND
alpha-HCH		80	0	ng/g wet	1	3	0.01	11	NA	All ND
beta-HCH		80	0	ng/g wet	2	1	0.00	1	NA	All ND
delta-HCH		80	0	ng/g wet	2	0	NA	NA	NA	All ND
gamma-HCH		80	0	ng/g wet	1	1	0.01	8	NA	All ND
heptachlor		80	0	ng/g wet	2	0	NA	NA	NA	All ND
heptachlor epoxide		80	0	ng/g wet	1	3	0.02	6	NA	All ND
hexachlorobenzene		80	0	ng/g wet	0.3	5	0.00	3	NA	All ND
methoxychlor		80	0	ng/g wet	5	0	NA	NA	NA	All ND
mirex		80	0	ng/g wet	3	2	0.01	30	NA	All ND
cis-Nonachlor	CHLOR	80	0	ng/g wet	2	5	0.07	8	18	All ND
trans-Nonachlor	CHLOR	80	2.17	ng/g wet	1	5	0.13	9	15	All ND
oxadiazon		80	0	ng/g wet	3	2	0.09	9	NA	All ND
oxychlordane	CHLOR	80	0	ng/g wet	1	4	0.02	8	NA	All ND
Ethyl Parathion		80	0	ng/g wet	2	0	NA	NA	NA	All ND
Methyl Parathion		80	0	ng/g wet	4	0	NA	NA	NA	All ND
toxaphene		80	0	ng/g wet	50	0	NA	NA	NA	All ND
% Moisture		134	76.50	%	NR	5	0.25	0	NA	NA
% Lipid		80	1.93	%	NR	5	0.11	10	NA	NA

a Indicates whether parameter is part of the total chlordane summation, or DDT summation. Blank cells are not part of either total.

b Duplicate laboratory analyses of field samples for which concentrations were above the detection limit.

c Mean absolute value of error of all analyses, using NIST Standard Reference Materials 2974 and/or 2978.

NA = not available

NR = Data not reported by lab

ND = not detected

Appendix Table 1d. Quality assurance and control summary for laboratory analysis of fish tissue (dioxins and coplanar PCBs).

Parameter	Number Samples	Median Field Sample	Units	MDL	Number Replicates ^a	SD Replicates ^a	Precision (RSD%)	Accuracy (% Error) ^b	Blank Mean
2,3,7,8-TCDD	38	0.10	pg/g wet	0.02	1	0.03	22	13	0.02
1,2,3,7,8-PCDD	38	0.22	pg/g wet	0.02	1	0.06	12	12	0.02
1,2,3,4,7,8-HxCDD	38	ND	pg/g wet	0.02	0	NA	NA	44	0.03
1,2,3,6,7,8-HxCDD	38	0.05	pg/g wet	0.02	1	0.02	6	30	0.03
1,2,3,7,8,9-HxCDD	38	ND	pg/g wet	0.02	0	NA	NA	31	0.02
1,2,3,4,6,7,8-HpCDD	38	0.09	pg/g wet	0.04	0	NA	NA	25	0.05
1,2,3,4,6,7,8,9-OCDD	38	0.27	pg/g wet	0.1	2	0.30	70	77	0.30
2,3,7,8-TCDF	38	1.71	pg/g wet	0.02	3	0.16	14	21	0.06
1,2,3,7,8-PCDF	38	0.21	pg/g wet	0.02	1	0.02	8	61	0.02
2,3,4,7,8-PCDF	38	0.69	pg/g wet	0.02	2	0.09	22	12	0.02
1,2,3,4,7,8-HxCDF	38	ND	pg/g wet	0.02	0	NA	NA	44	0.02
1,2,3,6,7,8-HxCDF	38	ND	pg/g wet	0.02	0	NA	NA	19	0.02
1,2,3,7,8,9-HxCDF	38	ND	pg/g wet	0.02	0	NA	NA	28	0.02
2,3,4,6,7,8-HxCDF	38	ND	pg/g wet	0.02	0	NA	NA	75	0.02
1,2,3,4,6,7,8-HpCDF	38	ND	pg/g wet	0.04	0	NA	NA	82	0.05
1,2,3,4,7,8,9-HpCDF	38	ND	pg/g wet	0.04	0	NA	NA	82	0.04
1,2,3,4,6,7,8,9-OCDF	38	ND	pg/g wet	0.1	0	NA	NA	37	0.09
PCB 077	38	54.20	pg/g wet	0.5	2	3.03	14	26	0.32
PCB 126	38	25.40	pg/g wet	0.5	2	2.93	11	2	0.21
PCB 169	38	1.87	pg/g wet	0.5	1	0.56	18	45	0.03

a. Blind duplicate laboratory analyses of field samples for which concentrations were above three times the detection limit.

b. Mean absolute value of error of all analyses, using Standard Reference Materials NRC CARP-1 and/or EDF2525 (from Cambridge Isotopes Lab).

ND = not detected.

NA = not available.

Appendix Table 2a. Mercury concentrations in fish, crab, and clam tissue samples, 1998-2000.

Sample ID	Fish ID	Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Length	Average Length	% Moisture	Hg (wet)	Hg (dry)
							cm	cm	%	µg/g	µg/g
I003606	33	6/13/00	S F Waterfront	California Halibut	Off	1	55	55	74.9	0.284	1.130
I003602	29	5/4/00	S F Waterfront	California Halibut	Off	1	64	64	76.3	0.323	1.360
I003601	28	5/3/00	S F Waterfront	California Halibut	Off	1	82	82	75.3	0.213	0.866
I003605	32	5/25/00	S F Waterfront	California Halibut	Off	1	84	84	76.4	0.195	0.828
I003603	30	5/4/00	S F Waterfront	California Halibut	Off	1	92	92	75.9	0.586	2.430
I003604	31	5/4/00	S F Waterfront	California Halibut	Off	1	98	98	75.6	0.451	1.850
I005603	80	7/20/00	San Pablo Bay	California Halibut	Off	1	51	51	75.6	0.126	0.516
I005601	78	6/2/00	San Pablo Bay	California Halibut	Off	1	55	55	76.0	0.192	0.800
I005602	79	6/8/00	San Pablo Bay	California Halibut	Off	1	61	61	75.4	0.174	0.708
I005604	81	7/27/00	San Pablo Bay	California Halibut	Off	1	75	75	75.4	0.209	0.850
C004301	142	5/24/00	Berkeley	Jacksnelt	WB	5	24 - 28	26.0	73.1	ND	ND
C004302	143	6/14/00	Berkeley	Jacksnelt	WB	5	25 - 28	26.6	73.8	ND	ND
C004303	144	6/15/00	Berkeley	Jacksnelt	WB	5	26 - 29	27.4	72.7	ND	ND
C002301	121	6/21/00	Oakland	Jacksnelt	WB	5	25 - 30	26.8	74.3	0.076	0.297
C002303	123	6/22/00	Oakland	Jacksnelt	WB	5	25 - 29	27.0	81.4	0.050	0.271
C002302	122	6/21/00	Oakland	Jacksnelt	WB	5	26 - 29	27.4	74.7	0.062	0.243
C003301	131	5/3/00	S F Waterfront	Jacksnelt	WB	5	24 - 27	25.8	76.6	0.047	0.202
C003302	132	5/4/00	S F Waterfront	Jacksnelt	WB	5	25 - 28	26.4	76.5	0.059	0.249
C003303	133	5/4/00	S F Waterfront	Jacksnelt	WB	5	25 - 28	26.6	77.0	0.054	0.234
C005303	159	6/2/00	San Pablo Bay	Jacksnelt	WB	5	25 - 29	27.0	76.8	0.072	0.310
C005301	157	6/2/00	San Pablo Bay	Jacksnelt	WB	5	26 - 28	27.2	77.6	0.079	0.353
C005302	158	6/2/00	San Pablo Bay	Jacksnelt	WB	5	27 - 28	27.6	77.2	0.068	0.299
C001303	96	5/1/00	South Bay Bridges	Jacksnelt	WB	5	26 - 29	27.4	76	0.053	0.220
C001302	95	5/1/00	South Bay Bridges	Jacksnelt	WB	5	27 - 28	27.8	75.7	0.116	0.478
C001301	94	5/1/00	South Bay Bridges	Jacksnelt	WB	5	27 - 29	28.4	69.1	0.063	0.204
C004201	139	5/5/00	Berkeley	Shiner Surfperch	WB	20	11 - 13	12.2	75.4	0.060	0.243
C004202	140	5/5/00	Berkeley	Shiner Surfperch	WB	20	11 - 14	12.5	76.5	0.068	0.288
C004203	141	5/5/00	Berkeley	Shiner Surfperch	WB	20	11 - 15	13.1	75.7	0.075	0.310
C002203	120	6/22/00	Oakland	Shiner Surfperch	WB	19	10 - 14	11.4	79.4	0.145	0.702
C002201	118	6/21/00	Oakland	Shiner Surfperch	WB	20	10 - 13	11.6	61.3	0.148	0.382
C002202	119	6/16/00	Oakland	Shiner Surfperch	WB	20	11 - 15	12.1	78.2	0.138	0.634
C003201	128	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10 - 14	11.3	77.2	0.058	0.254
C003203	130	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10 - 13	11.4	76.2	0.077	0.322
C003202	129	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10 - 13	11.5	77.1	0.067	0.294
C008203	172	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8 - 10	8.4	77.1	0.134	0.586
C008202	171	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9 - 11	9.9	77.4	0.139	0.614
C008201	170	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9 - 12	10.4	78.1	0.174	0.797
C005202	155	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 11	9.5	78.4	0.058	0.245
C005203	156	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 12	10.1	76.0	0.049	0.205
C005201	154	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 12	10.2	77.6	0.047	0.211
C001203	93	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	10 - 14	11.0	77.4	0.091	0.403
C001202	92	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11 - 14	12.5	76.5	0.095	0.405
C001201	91	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11 - 15	12.6	76.6	0.093	0.396
C004102	137	5/24/00	Berkeley	White Croaker	On	5	24 - 28	26.4	75.7	0.250	1.030
C004103	138	5/24/00	Berkeley	White Croaker	On	5	25 - 29	27.4	76.1	0.275	1.150
C004101	136	5/24/00	Berkeley	White Croaker	On	5	24 - 29	27.6	76.3	0.249	1.050
C002101	106	6/16/00	Oakland	White Croaker	On	5	21 - 28	24.0	74.3	0.151	0.587
C002102	107	6/20/00	Oakland	White Croaker	On	5	22 - 28	24.8	81.0	0.178	0.933
C002103	108	6/20/00	Oakland	White Croaker	On	5	24 - 29	27.4	73.7	0.169	0.645
C003103	127	5/3/00	S F Waterfront	White Croaker	On	5	22 - 27	24.8	76.4	0.185	0.782
C003102	126	5/3/00	S F Waterfront	White Croaker	On	5	25 - 28	26.6	77.6	0.191	0.853
C003101	125	5/3/00	S F Waterfront	White Croaker	On	5	25 - 30	27.6	76.6	0.204	0.870
C005101	151	6/8/00	San Pablo Bay	White Croaker	On	5	23 - 30	28.0	74.0	0.270	1.040
C005103	153	6/2/00	San Pablo Bay	White Croaker	On	5	25 - 30	28.0	73.5	0.217	0.820
C005102	152	6/8/00	San Pablo Bay	White Croaker	On	5	27 - 30	28.6	73.1	0.210	0.778
C001102	89	5/1/00	South Bay Bridges	White Croaker	On	5	24 - 30	26.4	74.4	0.212	0.828
C001101	88	5/1/00	South Bay Bridges	White Croaker	On	5	26 - 30	27.8	55.3	0.383	0.858
C001103	90	5/1/00	South Bay Bridges	White Croaker	On	5	26 - 30	27.8	76.1	0.258	1.080
I005701	82	3/21/00	San Pablo Bay	White Sturgeon	Off	1	115	115	78.5	0.205	0.954
I005703	84	3/22/00	San Pablo Bay	White Sturgeon	Off	1	117	117	80.8	0.171	0.891
I005702	83	3/22/00	San Pablo Bay	White Sturgeon	Off	1	125	125	79.5	0.278	1.360
I005705	86	3/23/00	San Pablo Bay	White Sturgeon	Off	1	133	133	80.7	0.233	1.210
I005706	87	3/24/00	San Pablo Bay	White Sturgeon	Off	1	147	147	77.4	0.215	0.951
I005704	85	3/22/00	San Pablo Bay	White Sturgeon	Off	1	149	149	81.2	0.203	1.080
I001703	24	4/19/00	South Bay Bridges	White Sturgeon	Off	1	121	121	78.4	0.331	1.530
I001705	26	5/18/00	South Bay Bridges	White Sturgeon	Off	1	122	122	79.3	0.369	1.780
I001702	23	4/19/00	South Bay Bridges	White Sturgeon	Off	1	130	130	79.9	0.297	1.480
I001706	27	5/19/00	South Bay Bridges	White Sturgeon	Off	1	135	135	78.5	0.463	2.150
I001704	25	4/20/00	South Bay Bridges	White Sturgeon	Off	1	149	149	77.6	0.498	2.220
I001701	22	4/19/00	South Bay Bridges	White Sturgeon	Off	1	182	182	76.3	0.707	2.980

Off = Skin-off muscle, On = Skin-on muscle, WB = Whole body

ND = not detected

Sample ID and Fish ID are unique identifiers for each individual or composite fish sample

Appendix Table 2a. Mercury concentrations in fish, crab, and clam tissue samples, 1998-2000 (continued).

Sample ID	Fish ID	Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Average Length	% Moisture	Hg (wet)	Hg (dry)
							cm	%	µg/g	µg/g
I004404	37	5/24/00	Berkeley	Leopard Shark	Off	1	86	76.6	0.768	3.280
I004401	34	5/24/00	Berkeley	Leopard Shark	Off	1	89	77.3	0.737	3.250
I004403	36	5/24/00	Berkeley	Leopard Shark	Off	1	90	76.4	0.867	3.680
I004405	38	5/25/00	Berkeley	Leopard Shark	Off	1	91	77.6	0.903	4.030
I004410	41	7/19/00	Berkeley	Leopard Shark	Off	1	92	75.4	0.800	3.260
I004411	42	7/19/00	Berkeley	Leopard Shark	Off	1	92	76.9	0.807	3.500
I004413	44	7/19/00	Berkeley	Leopard Shark	Off	1	92	75.1	0.703	2.830
I004402	35	5/24/00	Berkeley	Leopard Shark	Off	1	93	77.5	0.738	3.280
I004406	39	5/25/00	Berkeley	Leopard Shark	Off	1	99	77.4	1.010	4.460
I004407	40	5/25/00	Berkeley	Leopard Shark	Off	1	110	77.9	1.090	4.920
I004412	43	7/19/00	Berkeley	Leopard Shark	Off	1	113	77.1	0.902	3.940
I005401	57	6/6/00	San Pablo Bay	Leopard Shark	Off	1	90	76.8	0.320	1.380
I005402	58	6/6/00	San Pablo Bay	Leopard Shark	Off	1	90	77.7	0.843	3.790
I005408	64	6/9/00	San Pablo Bay	Leopard Shark	Off	1	90	78.1	0.687	3.140
I005404	60	6/7/00	San Pablo Bay	Leopard Shark	Off	1	91	76.9	0.803	3.470
I005406	62	6/7/00	San Pablo Bay	Leopard Shark	Off	1	93	74.8	0.666	2.640
I005407	63	6/8/00	San Pablo Bay	Leopard Shark	Off	1	93	78.5	0.651	3.030
I005409	65	7/20/00	San Pablo Bay	Leopard Shark	Off	1	98	74.8	0.756	3.000
I005403	59	6/6/00	San Pablo Bay	Leopard Shark	Off	1	107	76.1	0.874	3.660
I005405	61	6/7/00	San Pablo Bay	Leopard Shark	Off	1	107	77.7	0.824	3.700
I001407	7	5/17/00	South Bay Bndges	Leopard Shark	Off	1	92	78.6	0.955	4.460
I001403	3	5/16/00	South Bay Bndges	Leopard Shark	Off	1	98	77.3	0.941	4.150
I001408	8	5/17/00	South Bay Bndges	Leopard Shark	Off	1	100	78.1	0.705	3.220
I001402	2	5/16/00	South Bay Bndges	Leopard Shark	Off	1	101	78.2	1.190	5.480
I001409	9	5/18/00	South Bay Bndges	Leopard Shark	Off	1	101	77.4	0.748	3.310
I001410	10	5/23/00	South Bay Bndges	Leopard Shark	Off	1	103	77.1	0.813	3.550
I001406	6	5/17/00	South Bay Bndges	Leopard Shark	Off	1	109	78.9	1.210	5.750
I001411	11	5/23/00	South Bay Bndges	Leopard Shark	Off	1	109	76.7	1.090	4.700
I001405	5	5/17/00	South Bay Bndges	Leopard Shark	Off	1	118	77.6	1.260	5.630
I001412	12	5/23/00	South Bay Bndges	Leopard Shark	Off	1	120	77.9	1.510	6.830
I001401	1	5/16/00	South Bay Bndges	Leopard Shark	Off	1	125	77.5	1.600	7.090
I001404	4	5/17/00	South Bay Bndges	Leopard Shark	Off	1	134	78.0	1.380	6.290
I004503	47	5/25/00	Berkeley	Striped Bass	Off	1	48	75.4	0.241	0.977
I004501	45	5/24/00	Berkeley	Striped Bass	Off	1	51	78.1	0.299	1.370
I004504	48	5/25/00	Berkeley	Striped Bass	Off	1	51	78.5	0.378	1.760
I004511	56	7/19/00	Berkeley	Striped Bass	Off	1	51	76.2	0.281	1.180
I004505	49	5/26/00	Berkeley	Striped Bass	Off	1	53	75.4	0.329	1.340
I004508	52	6/14/00	Berkeley	Striped Bass	Off	1	54	77.1	0.340	1.490
I004502	46	5/25/00	Berkeley	Striped Bass	Off	1	55	75.8	0.224	0.927
I004506	50	5/26/00	Berkeley	Striped Bass	Off	1	56	79.4	0.491	2.390
I004510	55	6/15/00	Berkeley	Striped Bass	Off	1	61	74.1	0.316	1.220
I004509	54	6/14/00	Berkeley	Striped Bass	Off	1	62	74.5	0.349	1.370
I004507	51	5/26/00	Berkeley	Striped Bass	Off	1	78	78.0	0.484	2.200
I005508	73	6/2/00	San Pablo Bay	Striped Bass	Off	1	45	76.5	0.225	0.957
I005503	68	6/2/00	San Pablo Bay	Striped Bass	Off	1	50	76.4	0.205	0.871
I005506	71	6/2/00	San Pablo Bay	Striped Bass	Off	1	50	74.6	0.188	0.740
I005502	67	6/2/00	San Pablo Bay	Striped Bass	Off	1	51	76.2	0.235	0.986
I005504	69	6/2/00	San Pablo Bay	Striped Bass	Off	1	51	76.2	0.289	1.210
I005511	76	6/2/00	San Pablo Bay	Striped Bass	Off	1	54	75.2	0.251	1.010
I005509	74	6/2/00	San Pablo Bay	Striped Bass	Off	1	55	75.0	0.342	1.370
I005505	70	6/2/00	San Pablo Bay	Striped Bass	Off	1	57	74.2	0.273	1.060
I005507	72	6/2/00	San Pablo Bay	Striped Bass	Off	1	58	76.4	0.300	1.270
I005510	75	6/2/00	San Pablo Bay	Striped Bass	Off	1	60	74.2	0.284	1.100
I005501	66	6/2/00	San Pablo Bay	Striped Bass	Off	1	62	75.5	0.243	0.991
I005512	77	6/8/00	San Pablo Bay	Striped Bass	Off	1	75	73.3	0.370	1.390
I001507	19	5/19/00	South Bay Bndges	Striped Bass	Off	1	45	79.0	0.190	0.905
I001506	18	5/19/00	South Bay Bndges	Striped Bass	Off	1	46	76.5	0.169	0.723
I001501	13	5/18/00	South Bay Bndges	Striped Bass	Off	1	47	77.0	0.219	0.951
I001502	14	5/18/00	South Bay Bndges	Striped Bass	Off	1	47	77.9	0.186	0.842
I001505	17	5/19/00	South Bay Bndges	Striped Bass	Off	1	47	75.2	0.285	1.150
I001504	16	5/19/00	South Bay Bndges	Striped Bass	Off	1	49	75.7	0.242	0.994
I001509	21	5/23/00	South Bay Bndges	Striped Bass	Off	1	50	76.3	0.331	1.400
I001503	15	5/18/00	South Bay Bndges	Striped Bass	Off	1	52	78.9	0.264	1.250
I001508	20	5/23/00	South Bay Bndges	Striped Bass	Off	1	57	77.8	0.295	1.330
C993A01		9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	M	10	12.3	82.0	0.124	0.692
C993A02		9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	M	10	12.2	80.0	0.169	0.843
C993A03		9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	H	20	12.3	83.8	0.048	0.295
C993B01		9/29/99	Fort Baker	Red Rock Crab	M	10	11.1	76.3	0.130	0.598
C993B02		9/29/99	Fort Baker	Red Rock Crab	M	10	11.3	81.0	0.078	0.414
C993B03		9/29/99	Fort Baker	Red Rock Crab	H	20	11.2	79.5	0.051	0.248
C993C01		9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	M	10	12.1	78.1	0.143	0.653
C993C02		9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	M	10	11.2	76.8	0.155	0.669
C993C03		9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	H	20	11.7	72.4	0.077	0.281
C981A01		4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	NA	87.5	0.108	0.897
C982A01		4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	All	25	NA	88.0	0.048	0.380

Off = Skin-off muscle, On = Skin-on muscle, WB = Whole body, M = Crab muscle, H = Crab hepatopancreas, All = Clam soft tissue
 NA = not available

Appendix Table 2b. PCB concentrations in fish, crab, and clam tissue samples, 1998-2000.

Sample ID	Fish ID	Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths	Average Length	% Lipids	% Moisture	Aroclor 1248	Aroclor 1254	Aroclor 1260	Total Aroclors
							cm	cm	%	%	ng/g	ng/g	ng/g	ng/g
C003601	134	5/3/00	S F Waterfront	California Halibut	Off	3	55, 64, 82	67.0	0.4	76.4	ND	30	12	42
C003602	135	5/4/00	S F Waterfront	California Halibut	Off	3	84, 92, 98	91.3	0.3	76.1	ND	17	ND	17
C005601	187	6/2/00	San Pablo Bay	California Halibut	Off	3	55, 61, 75	63.7	0.4	77.3	ND	24	ND	24
C004301	142	5/24/00	Berkeley	Jacksmelt	WB	5	24 - 28	26.0	2.6	74.8	ND	11	ND	11
C004302	143	6/14/00	Berkeley	Jacksmelt	WB	5	25 - 28	26.6	2.5	73.7	ND	20	ND	20
C004303	144	6/15/00	Berkeley	Jacksmelt	WB	5	26 - 29	27.4	3.0	73.8	ND	14	ND	14
C002301	121	6/21/00	Oakland	Jacksmelt	WB	5	25 - 30	26.8	1.5	74.8	ND	120	25	145
C002302	122	6/21/00	Oakland	Jacksmelt	WB	5	26 - 29	27.4	2.3	75.2	ND	55	ND	55
C002303	123	6/22/00	Oakland	Jacksmelt	WB	5	25 - 29	27.0	2.1	74.6	ND	39	ND	39
C003301	131	5/3/00	S F Waterfront	Jacksmelt	WB	5	24 - 27	25.8	1.0	76.5	ND	23	ND	23
C003302	132	5/4/00	S F Waterfront	Jacksmelt	WB	5	25 - 28	26.4	1.0	76.8	ND	30	ND	30
C003303	133	5/4/00	S F Waterfront	Jacksmelt	WB	5	25 - 28	26.6	1.4	75.7	ND	36	ND	36
C005301	157	6/2/00	San Pablo Bay	Jacksmelt	WB	5	26 - 28	27.2	0.8	78.2	ND	37	12	49
C005302	158	6/2/00	San Pablo Bay	Jacksmelt	WB	5	27 - 28	27.6	0.6	77.9	ND	30	ND	30
C005303	159	6/2/00	San Pablo Bay	Jacksmelt	WB	5	27 - 28	27.0	0.7	77.2	ND	41	ND	41
C001301	94	5/1/00	South Bay Bridges	Jacksmelt	WB	5	27 - 29	28.4	1.2	76.4	ND	45	24	69
C001302	95	5/1/00	South Bay Bridges	Jacksmelt	WB	5	27 - 28	27.8	1.2	76.6	ND	100	29	129
C001303	96	5/1/00	South Bay Bridges	Jacksmelt	WB	5	26 - 29	27.4	1.4	76.5	ND	41	21	62
C004402	146	5/24/00	Berkeley	Leopard Shark	Off	3	92, 92, 93	92.3	0.4	77.0	ND	ND	ND	0
C004403	147	5/25/00	Berkeley	Leopard Shark	Off	3	99, 110, 113	107.3	0.4	77.2	ND	26	ND	26
C005402	161	6/7/00	San Pablo Bay	Leopard Shark	Off	3	90, 91, 93	91.3	0.7	78.6	ND	14	ND	14
C005403	162	6/6/00	San Pablo Bay	Leopard Shark	Off	3	98, 107, 107	104.0	0.4	77.3	ND	ND	ND	0
C001404	100	5/16/00	South Bay Bridges	Leopard Shark	Off	3	120, 125, 134	128.3	0.4	77.5	ND	43	15	58
C001401	97	5/16/00	South Bay Bridges	Leopard Shark	Off	3	92, 95, 100	96.7	0.4	78.0	ND	29	10	39
C004201	139	5/5/00	Berkeley	Shiner Surfperch	WB	20	11 - 13	12.2	4.1	75.8	ND	83	32	115
C004202	140	5/5/00	Berkeley	Shiner Surfperch	WB	20	11 - 14	12.5	3.6	76.6	ND	120	40	160
C004203	141	5/5/00	Berkeley	Shiner Surfperch	WB	20	11 - 15	13.1	3.6	76.1	ND	120	37	157
C002201	118	6/21/00	Oakland	Shiner Surfperch	WB	20	10 - 13	11.6	1.1	79.0	ND	310	83	393
C002202	119	6/16/00	Oakland	Shiner Surfperch	WB	20	11 - 15	12.1	1.3	78.4	ND	380	100	480
C002203	120	6/22/00	Oakland	Shiner Surfperch	WB	18	10 - 14	11.4	0.8	79.9	ND	270	76	346
C003201	128	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10 - 14	11.3	2.6	77.0	ND	95	40	135
C003202	129	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10 - 13	11.5	3.8	75.9	ND	140	46	186
C003203	130	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10 - 13	11.4	2.8	76.3	ND	160	49	209
C008201	170	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9 - 12	10.4	2.5	77.4	ND	510	73	583
C008202	171	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9 - 11	9.9	2.2	77.4	ND	430	67	497
C008203	172	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8 - 10	8.4	2.1	77.6	ND	390	68	458
C005201	154	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 12	10.2	3.0	77.4	ND	60	13	73
C005202	155	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 11	9.5	3.1	76.4	ND	72	12	84
C005203	156	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 12	10.1	3.6	76.2	ND	70	15	85
C001201	91	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11 - 15	12.8	2.4	76.9	ND	190	67	257
C001202	92	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11 - 14	12.5	2.6	77.3	ND	150	54	204
C001203	93	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	10 - 14	11.0	2.0	77.8	220	135	46	401
C004501	148	5/24/00	Berkeley	Striped Bass	Off	3	48, 51, 54	51.0	0.8	77.7	ND	42	32	74
C004502	149	5/25/00	Berkeley	Striped Bass	Off	3	51, 51, 53	51.7	0.7	77.8	ND	55	26	81
C004503	150	5/26/00	Berkeley	Striped Bass	Off	3	61, 62, 78	67.0	1.4	76.7	ND	60	32	92
C005501	163	6/2/00	San Pablo Bay	Striped Bass	Off	3	45, 51, 58	51.3	1.3	77.2	ND	37	13	50
C005502	164	6/2/00	San Pablo Bay	Striped Bass	Off	3	50, 54, 55	53.0	1.1	76.5	ND	28	10	38
C005503	165	6/2/00	San Pablo Bay	Striped Bass	Off	3	50, 51, 57	52.7	1.5	75.5	ND	11	46	57
C005504	166	6/2/00	San Pablo Bay	Striped Bass	Off	3	60, 62, 75	65.7	1.1	76.0	ND	27	ND	27
C001501	101	5/18/00	South Bay Bridges	Striped Bass	Off	3	47, 49, 50	48.7	1.2	77.0	ND	64	28	92
C001502	102	5/16/00	South Bay Bridges	Striped Bass	Off	3	45, 47, 52	48.0	1.2	77.2	ND	33	13	46
C001503	103	5/18/00	South Bay Bridges	Striped Bass	Off	3	46, 47, 57	50.0	1.0	77.8	ND	35	11	46
C004101	136	5/24/00	Berkeley	White Croaker	On	5	24 - 29	27.6	2.3	74.9	ND	200	65	265
C004102	137	5/24/00	Berkeley	White Croaker	On	5	24 - 28	26.4	2.7	76.1	ND	87	47	134
C004103	138	5/24/00	Berkeley	White Croaker	On	5	25 - 29	27.4	3.0	76.6	ND	130	60	190
C002101	106	6/16/00	Oakland	White Croaker	On	5	21 - 28	24.0	4.8	74.0	ND	330	110	440
C002102	107	6/20/00	Oakland	White Croaker	On	5	22 - 28	24.8	6.3	74.0	ND	210	66	278
C002103	108	6/20/00	Oakland	White Croaker	On	5	24 - 29	27.4	5.7	73.8	ND	420	120	540
C002104	109	3/6/00	Oakland	White Croaker	On	5	23 - 27	25.2	1.9	74.5	ND	140	56	196
C002105	110	3/8/00	Oakland	White Croaker	On	5	22 - 25	23.6	1.0	78.0	ND	51	33	84
C002106	111	3/8/00	Oakland	White Croaker	On	5	21 - 28	24.8	1.8	75.7	ND	150	83	213
C002107	112	9/26/00	Oakland	White Croaker	On	5	22 - 29	25.4	6.0	73.2	ND	430	120	550
C002108	113	9/26/00	Oakland	White Croaker	On	5	22 - 30	25.6	7.3	72.6	ND	370	110	480
C002109	114	9/26/00	Oakland	White Croaker	On	5	21 - 30	26.0	5.5	73.1	ND	300	97	397
C002110	115	12/18/00	Oakland	White Croaker	On	5	21 - 30	23.8	6.3	73.0	ND	360	110	513
C002111	116	12/18/00	Oakland	White Croaker	On	4	22 - 29	25.5	4.1	74.1	ND	200	63	263
C002112	117	12/18/00	Oakland	White Croaker	On	5	21 - 27	23.4	4.8	73.9	ND	210	64	274
C003101	125	5/3/00	S F Waterfront	White Croaker	On	5	25 - 30	27.6	2.0	77.4	ND	160	70	230
C003102	126	5/3/00	S F Waterfront	White Croaker	On	5	25 - 28	26.6	1.8	77.8	ND	190	73	263
C003103	127	5/3/00	S F Waterfront	White Croaker	On	5	22 - 27	24.8	2.2	76.3	ND	130	60	190
C005101	151	6/8/00	San Pablo Bay	White Croaker	On	5	23 - 30	28.0	4.9	74.7	ND	270	110	380
C005102	152	6/8/00	San Pablo Bay	White Croaker	On	5	27 - 30	28.6	5.3	73.8	ND	250	90	340
C005103	153	6/2/00	San Pablo Bay	White Croaker	On	5	25 - 30	28.0	4.4	74.2	ND	190	68	258
C001101	88	5/1/00	South Bay Bridges	White Croaker	On	5	25 - 30	27.8	2.8	75.9	ND	570	100	670
C001102	89	5/1/00	South Bay Bridges	White Croaker	On	5	24 - 30	28.4	4.4	74.3	ND	190	63	253
C001103	90	5/1/00	South Bay Bridges	White Croaker	On	5	26 - 30	27.8	4.0	76.5	ND	220	86	306
C005701	168	3/21/00	San Pablo Bay	White Sturgeon	Off	3	115, 117, 125	119.0	0.6	79.6	ND	20	ND	20
C006702	169	3/22/00	San Pablo Bay	White Sturgeon	Off	3	133, 147, 149	143.0	1.8	78.2	ND	52	10	62
C001701	104	4/19/00	South Bay Bridges	White Sturgeon	Off	3	121, 122, 123	124.3	0.5	79.7	ND	29	13	42
C001702	105	4/19/00	South Bay Bridges	White Sturgeon	Off	3	135, 149, 182	155.3	0.8	77.7	ND	51	17	68
C993A01		9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	10 - 15	12.3	0.1	82.9	NA	NA	NA	NA
C993A02		9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	10 - 15	12.2	0.2	79.0	NA	NA	NA	NA
C993A03		9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	H	20	10 - 15	12.3	3.1	84.3	NA	NA	NA	NA
C993B01		9/29/99	Fort Baker	Red Rock Crab	M	10	10 - 13	11.1	0.2	79.0	NA	NA	NA	NA
C993B02		9/29/99	Fort Baker	Red Rock Crab	M	10	10 - 13	11.3	0.2	82.4	NA	NA	NA	NA
C993B03		9/29/99	Fort Baker	Red Rock Crab	H	20	10 - 13	11.2	4.3	79.4	NA	NA	NA	NA
C993C01		9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	M	10	10 - 13	12.1	0.2	77.6	NA	NA	NA	NA
C993C02		9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	M	10	10 - 13	11.2	0.4	76.9	NA	NA	NA	NA
C993C03		9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	H	20	10 - 13	11.7	8.5	72.8	NA	NA	NA	NA
C981A01		4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	3.7 - 4.5	NA	0.8	87.5	NA	NA	NA	NA
C982A01		4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	All	25	3.3 - 4.5	NA	0.9	88.0	NA	NA	NA	NA

Units expressed as wet weight. Off = Skin-off muscle, On = Skin-on muscle, WB = Whole body, M = muscle, H = hepatopancreas, All = clam soft tissue
 b = blank contamination <30% of measured concentration, B = blank contamination >30% of measured concentration,
 e = estimated value, ND = not detected, NA = not available
 Sample ID and Fish ID are unique identifiers for each individual or composite fish sample

Appendix Table 2b. PCB concentrations in fish, crab, and clam tissue samples, 1998-2000 (continued).

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Average Length cm	% Lipids	Sum of PCBs (SFE)	PCB 008	PCB 019	PCB 028	PCB 031	PCB 033	PCB 044	PCB 049	PCB 052	PCB 056
5/3/00	S F Waterfront	California Halibut	Off	3	67.0	0.4	28	ND	ND	ND	ND	ND	ND	ND	0.3	ND
5/4/00	S F Waterfront	California Halibut	Off	3	91.3	0.3	17	ND	ND	ND	ND	ND	ND	ND	0.2	ND
6/2/00	San Pablo Bay	California Halibut	Off	3	63.7	0.4	22	ND	ND	ND	ND	ND	ND	ND	0.4	ND
5/24/00	Berkeley	Jacksmelt	WB	5	26.0	2.6	9	ND	ND	ND	ND	ND	ND	ND	0.2	ND
6/14/00	Berkeley	Jacksmelt	WB	5	26.6	2.5	17	ND	ND	ND	ND	ND	ND	ND	0.3	ND
6/15/00	Berkeley	Jacksmelt	WB	5	27.4	3.0	10	ND	ND	ND	ND	ND	ND	ND	0.3	ND
6/21/00	Oakland	Jacksmelt	WB	5	26.8	1.5	105	NA	ND	0.6	e 0.5	ND	1.0	1.2	2.3	ND
6/21/00	Oakland	Jacksmelt	WB	5	27.4	2.3	51	NA	ND	0.3	e 0.3	ND	0.5	0.6	1.2	ND
6/22/00	Oakland	Jacksmelt	WB	5	27.0	2.1	38	NA	ND	0.3	e 0.3	ND	0.5	0.7	1.3	ND
5/3/00	S F Waterfront	Jacksmelt	WB	5	25.8	1.0	20	ND	ND	ND	ND	ND	ND	0.2	0.4	ND
5/4/00	S F Waterfront	Jacksmelt	WB	5	26.4	1.0	26	ND	ND	ND	ND	ND	ND	0.2	0.4	ND
5/4/00	S F Waterfront	Jacksmelt	WB	5	26.8	1.4	32	ND	ND	ND	ND	ND	0.2	0.3	0.5	ND
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.2	0.8	34	ND	ND	ND	ND	ND	ND	0.3	0.4	ND
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.8	0.6	26	ND	ND	ND	ND	ND	ND	0.2	0.3	ND
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.0	0.7	35	ND	ND	ND	ND	ND	ND	0.2	0.4	ND
5/1/00	South Bay Bridges	Jacksmelt	WB	5	28.4	1.2	57	NA	ND	0.5	0.5	ND	0.6	0.7	1.3	ND
5/1/00	South Bay Bridges	Jacksmelt	WB	5	27.8	1.2	79	NA	ND	0.2	0.2	ND	0.3	0.5	0.9	ND
5/1/00	South Bay Bridges	Jacksmelt	WB	5	27.4	1.4	49	NA	ND	0.3	0.3	ND	0.4	0.6	1.1	ND
5/24/00	Berkeley	Leopard Shark	Off	3	92.3	0.4	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/25/00	Berkeley	Leopard Shark	Off	3	107.3	0.4	18	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/7/00	San Pablo Bay	Leopard Shark	Off	3	91.3	0.7	8	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6/00	San Pablo Bay	Leopard Shark	Off	3	104.0	0.4	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/16/00	South Bay Bridges	Leopard Shark	Off	3	126.3	0.4	43	NA	ND	ND	ND	ND	0.3	0.4	0.6	ND
5/16/00	South Bay Bridges	Leopard Shark	Off	3	95.7	0.4	20	NA	ND	ND	ND	ND	ND	ND	ND	ND
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.2	4.1	85	ND	ND	0.3	e 0.3	ND	0.5	0.8	1.5	0.4
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.5	3.6	103	ND	ND	0.3	e 0.3	ND	0.4	0.8	1.5	0.3
5/5/00	Berkeley	Shiner Surfperch	WB	20	13.1	3.8	100	ND	ND	0.4	e 0.3	ND	0.6	1.0	1.7	ND
6/21/00	Oakland	Shiner Surfperch	WB	20	11.6	1.1	228	NA	ND	0.8	e 0.3	ND	1.3	2.2	3.7	ND
6/16/00	Oakland	Shiner Surfperch	WB	20	12.1	1.3	282	NA	ND	0.9	e 0.4	ND	1.4	2.8	4.7	1.0
6/22/00	Oakland	Shiner Surfperch	WB	19	11.4	0.8	212	NA	ND	0.6	e 0.3	ND	1.1	1.7	3.1	0.3
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.3	2.6	102	ND	ND	0.3	e 0.2	ND	0.4	0.7	1.5	ND
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.5	3.8	121	ND	ND	0.3	e 0.2	ND	0.4	0.8	1.6	ND
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.4	2.8	137	ND	ND	0.3	e 0.3	ND	0.5	0.9	2.0	ND
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	10.4	2.5	328	ND	0.3	1.3	e 0.7	ND	2.1	3.8	6.6	0.4
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9.8	2.2	276	ND	0.2	1.0	e 0.6	ND	1.7	2.9	5.2	ND
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8.4	2.1	262	ND	ND	1.0	e 0.6	ND	1.8	2.7	5.1	ND
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.2	3.0	54	ND	ND	0.4	e 0.3	ND	0.6	0.9	1.4	ND
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9.5	3.1	58	ND	ND	0.3	e 0.2	ND	0.5	0.8	1.4	ND
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.1	3.6	87	ND	ND	0.7	e 0.5	ND	1.0	1.4	2.3	ND
5/1/00	South Bay Bndges	Shiner Surfperch	WB	20	12.6	2.4	174	NA	0.2	1.1	0.8	ND	1.0	1.6	2.8	0.4
5/1/00	South Bay Bndges	Shiner Surfperch	WB	20	12.5	2.6	133	NA	ND	0.8	0.6	ND	0.7	1.1	2.0	ND
5/1/00	South Bay Bndges	Shiner Surfperch	WB	20	11.0	2.0	185	NA	4.3	10.0	7.1	1.0	4.4	5.3	8.2	0.7
5/24/00	Berkeley	Striped Bass	Off	3	51.0	0.8	53	ND	ND	ND	ND	ND	0.3	0.5	0.7	ND
5/25/00	Berkeley	Striped Bass	Off	3	51.7	0.7	60	ND	ND	0.2	ND	ND	0.4	0.5	0.8	ND
5/26/00	Berkeley	Striped Bass	Off	3	67.0	1.4	75	ND	0.2	0.6	e 0.4	ND	0.7	0.9	1.4	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	51.3	1.3	38	ND	ND	ND	ND	ND	0.2	0.3	0.5	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	53.0	1.1	27	ND	ND	ND	ND	ND	0.2	0.3	0.5	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	52.7	1.5	34	ND	ND	0.2	ND	ND	0.3	0.4	0.6	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	65.7	1.1	24	ND	ND	ND	ND	ND	0.2	0.3	0.5	ND
5/18/00	South Bay Bndges	Striped Bass	Off	3	48.7	1.2	51	NA	ND	ND	ND	ND	ND	ND	ND	ND
5/18/00	South Bay Bndges	Striped Bass	Off	3	48.0	1.2	34	NA	ND	ND	ND	ND	0.2	0.3	0.5	ND
5/18/00	South Bay Bndges	Striped Bass	Off	3	50.0	1.0	34	NA	ND	ND	ND	ND	0.3	0.4	0.6	ND
5/24/00	Berkeley	White Croaker	On	5	27.6	2.3	191	ND	ND	0.3	ND	ND	0.7	1.2	1.8	0.2
5/24/00	Berkeley	White Croaker	On	5	26.4	2.7	100	ND	ND	0.3	e 0.2	ND	0.6	0.8	1.3	ND
5/24/00	Berkeley	White Croaker	On	5	27.4	3.0	128	ND	ND	0.3	e 0.2	ND	0.6	0.9	1.2	0.2
6/16/00	Oakland	White Croaker	On	5	24.0	4.8	281	NA	0.2	1.1	0.5	ND	1.9	2.9	4.2	0.7
6/20/00	Oakland	White Croaker	On	5	24.8	6.3	196	NA	ND	0.9	0.6	ND	1.4	2.2	3.1	0.3
6/20/00	Oakland	White Croaker	On	5	27.4	5.7	354	NA	0.4	1.5	e 0.9	0.2	2.4	3.7	5.3	0.7
3/8/00	Oakland	White Croaker	On	5	25.2	1.9	134	NA	ND	0.7	e 0.4	ND	1.1	1.4	2.4	0.3
3/8/00	Oakland	White Croaker	On	5	23.6	1.0	61	NA	ND	0.3	ND	ND	0.4	0.5	0.9	ND
9/26/00	Oakland	White Croaker	On	5	24.8	1.8	149	NA	ND	0.7	e 0.5	ND	1.1	1.5	2.4	0.2
9/26/00	Oakland	White Croaker	On	5	25.4	6.0	367	NA	0.2	1.9	e 1.0	ND	2.1	4.7	6.9	0.5
9/26/00	Oakland	White Croaker	On	5	25.6	7.3	313	NA	ND	1.2	e 0.6	ND	1.4	3.0	4.3	0.6
9/26/00	Oakland	White Croaker	On	5	26.0	5.5	263	NA	ND	1.1	e 0.6	ND	1.5	2.7	4.0	0.6
12/18/00	Oakland	White Croaker	On	5	23.8	6.3	324	NA	0.5	2.2	e 1.3	0.2	2.6	4.4	6.8	0.9
12/18/00	Oakland	White Croaker	On	4	25.5	4.1	186	NA	0.2	1.0	e 0.5	ND	1.3	2.1	3.0	0.3
12/18/00	Oakland	White Croaker	On	5	23.4	4.9	180	NA	0.3	1.0	e 0.6	ND	1.5	2.2	3.5	0.3
5/3/00	S F Waterfront	White Croaker	On	5	27.6	2.0	155	NA	ND	0.4	e 0.2	ND	0.8	1.2	2.1	ND
5/3/00	S F Waterfront	White Croaker	On	5	26.6	1.8	179	NA	ND	0.4	e 0.2	ND	0.8	1.4	2.1	ND
5/3/00	S F Waterfront	White Croaker	On	5	24.8	2.2	126	ND	ND	0.3	ND	ND	0.7	0.9	1.5	0.4
6/8/00	San Pablo Bay	White Croaker	On	5	28.0	4.9	254	ND	ND	0.5	e 0.4	ND	1.1	1.7	2.3	0.4
6/8/00	San Pablo Bay	White Croaker	On	5	28.6	5.3	220	ND	ND	0.5	e 0.3	ND	1.1	1.7	2.4	1.2
6/2/00	San Pablo Bay	White Croaker	On	5	28.0	4.4	169	ND	ND	0.4	e 0.2	ND	0.8	1.2	1.8	0.3
5/1/00	South Bay Bndges	White Croaker	On	5	27.8	2.8	229	NA	ND	0.5	0.3	ND	0.8	1.4	2.0	0.2
5/1/00	South Bay Bndges	White Croaker	On	5	26.4	4.4	171	NA	ND	0.7	0.4	ND	1.1	1.6	2.4	0.4
5/1/00	South Bay Bndges	White Croaker	On	5	27.8	4.0	205	NA	ND	0.7	0.4	ND	1.1	1.6	2.4	0.3
3/21/00	San Pablo Bay	White Sturgeon	Off	3	119.0	0.6	20	ND	ND	ND	ND	ND	ND	ND	0.3	ND
3/22/00	San Pablo Bay	White Sturgeon	Off	3	143.0	1.8	54	ND	ND	0.2	ND	ND	0.3	0.5	1.0	ND
4/19/00	South Bay Bridges	White Sturgeon	Off	3	124.3	0.5	31	NA	ND	ND	ND	ND	ND	0.2	0.4	ND
4/19/00	South Bay Bridges	White Sturgeon	Off	3	155.3	0.8	55	NA	ND	0.2	ND	ND	ND	0.3	0.6	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	12.3	0.1	4	ND	ND	0.2	ND	ND	ND	ND	ND	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	12.2	0.2	7	ND	ND	0.4	ND	ND	ND	ND	0.3	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	H	20	12.3	3.1	87	ND	ND	0.7	0.4	ND	0.4	0.6	1.7	ND
9/29/99	Fort Baker	Red Rock Crab	M	10	11.1	0.2	6	ND	ND	0.3	ND	ND	ND	ND	0.3	ND
9/29/99	Fort Baker	Red Rock Crab	M	10	11.3	0.2	2	ND	ND	0.2	ND	ND	ND	ND	0.2	ND
9/29/99	Fort Baker	Red Rock Crab	H	20	11.2	4.3	109	ND	ND	0.6	0.3	ND	0.4	0.7	1.8	ND
9/30/99	SF Waterfront (7th St. Pier)	Red Rock Crab	M	10	12.1	0.2	6	ND	ND	0.3	ND	ND	ND	ND	0.3	ND
9/30/99	SF Waterfront (7th St. Pier)	Red Rock Crab	M	10	11.2	0.4	4	ND	ND	0.3	ND	ND	ND	ND	0.2	ND
9/30/99	SF Waterfront (7th St. Pier)	Red Rock Crab	H	20	11.7	8.5	181	ND	ND	0.8	0.6	ND	0.8	1.2	2.9	ND
4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	NA	0.8	5	ND	ND	ND	ND	ND	ND	ND	0.2	ND
4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	All	25	NA	0.9	21	ND	ND							

Appendix Table 2b. PCB concentrations in fish, crab, and clam tissue samples, 1998-2000
(continued).

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Average Length cm	Sum of PCBs (SFEI)												
						% Lipids	PCB 060	PCB 066	PCB 070	PCB 074	PCB 087	PCB 095	PCB 097	PCB 099	PCB 101	PCB 105		
						ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g		
5/3/00	S F Waterfront	California Halibut	Off	3	67.0	0.4	28	ND	0.2	ND	ND	0.4	0.3	ND	0.9	1.8	0.5	
5/4/00	S F Waterfront	California Halibut	Off	3	91.3	0.3	17	ND	ND	ND	ND	0.3	0.2	ND	0.6	1.0	0.3	
6/2/00	San Pablo Bay	California Halibut	Off	3	63.7	0.4	22	ND	0.3	0.2	ND	0.3	0.3	ND	0.8	1.4	0.5	
5/24/00	Berkeley	Jacksnelt	WB	5	26.0	2.6	9	ND	0.2	ND	ND	0.3	0.3	ND	0.4	0.7	0.3	
6/14/00	Berkeley	Jacksnelt	WB	5	26.6	2.5	17	ND	0.3	0.2	ND	0.4	0.5	ND	0.6	1.1	0.3	
6/15/00	Berkeley	Jacksnelt	WB	5	27.4	3.0	10	ND	0.3	ND	ND	0.4	0.3	ND	0.5	0.9	0.3	
6/21/00	Oakland	Jacksnelt	WB	5	26.8	1.5	105	0.2	1.7	b,e 1.2	0.8	1.6	3.1	1.2	3.8	b 7.7	1.8	
6/21/00	Oakland	Jacksnelt	WB	5	27.4	2.3	51	ND	0.9	B,e	0.5	1.1	1.6	0.7	2.0	b 4.2	1.0	
6/22/00	Oakland	Jacksnelt	WB	5	27.0	2.1	38	ND	0.8	b,e 0.7	0.4	0.9	1.5	0.8	1.5	b 3.2	0.8	
5/3/00	S F Waterfront	Jacksnelt	WB	5	25.8	1.0	20	ND	0.4	0.3	ND	0.5	0.7	0.3	0.8	1.4	0.4	
5/4/00	S F Waterfront	Jacksnelt	WB	5	26.4	1.0	26	ND	0.4	0.3	ND	0.5	0.8	0.3	0.9	1.6	0.5	
5/4/00	S F Waterfront	Jacksnelt	WB	5	26.6	1.4	32	ND	0.6	0.3	0.2	0.6	0.8	0.3	1.2	2.0	0.5	
6/2/00	San Pablo Bay	Jacksnelt	WB	5	27.2	0.8	34	ND	0.4	0.3	ND	0.5	0.7	0.3	1.3	2.0	0.4	
6/2/00	San Pablo Bay	Jacksnelt	WB	5	27.6	0.6	28	ND	0.4	0.2	ND	0.4	0.6	0.3	1.0	1.6	0.4	
6/2/00	San Pablo Bay	Jacksnelt	WB	5	27.0	0.7	35	ND	0.5	0.2	0.2	0.6	0.7	0.3	1.4	2.1	0.5	
5/1/00	South Bay Bridges	Jacksnelt	WB	5	28.4	1.2	57	0.2	1.2	0.8	0.5	1.1	1.6	0.6	1.6	3.4	0.9	
5/1/00	South Bay Bridges	Jacksnelt	WB	5	27.8	1.2	79	ND	1.1	0.6	0.5	1.0	1.3	0.6	3.4	3.4	1.3	
5/1/00	South Bay Bridges	Jacksnelt	WB	5	27.4	1.4	49	0.2	1.0	0.7	0.4	1.0	1.4	0.6	1.7	3.1	1.5	
5/24/00	Berkeley	Leopard Shark	Off	3	92.3	0.4	5	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	
5/25/00	Berkeley	Leopard Shark	Off	3	107.3	0.4	18	ND	0.3	ND	ND	ND	ND	ND	0.9	ND	0.3	
6/7/00	San Pablo Bay	Leopard Shark	Off	3	91.3	0.7	8	ND	ND	ND	ND	ND	ND	ND	0.5	ND	0.2	
6/6/00	San Pablo Bay	Leopard Shark	Off	3	104.0	0.4	5	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	
5/16/00	South Bay Bridges	Leopard Shark	Off	3	128.3	0.4	43	ND	0.6	0.3	ND	0.8	0.9	0.5	1.5	2.6	0.6	
5/16/00	South Bay Bridges	Leopard Shark	Off	3	96.7	0.4	20	ND	0.4	ND	ND	ND	ND	ND	1.1	0.2	0.4	
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.2	4.1	85	ND	0.7	0.9	0.7	1.2	1.8	0.4	3.2	5.3	1.5	
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.5	3.6	103	ND	0.8	0.9	0.7	1.4	1.8	0.5	3.7	5.9	1.9	
5/5/00	Berkeley	Shiner Surfperch	WB	20	13.1	3.6	100	0.4	1.0	1.1	0.8	1.4	1.9	0.5	3.6	6.2	2.0	
6/21/00	Oakland	Shiner Surfperch	WB	20	11.8	1.1	228	0.2	2.8	b,e 1.5	1.8	3.4	4.3	1.7	9.8	b 17.2	5.1	
6/16/00	Oakland	Shiner Surfperch	WB	20	12.1	1.3	282	0.3	3.7	b 2.1	2.3	4.5	5.4	2.2	11.7	b 21.6	6.1	
6/22/00	Oakland	Shiner Surfperch	WB	19	11.4	0.8	212	0.3	2.3	b,e 1.4	1.5	3.0	3.6	1.4	8.0	b 14.7	4.2	
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.3	2.6	102	ND	0.4	0.8	0.6	1.5	2.1	0.4	3.2	5.7	1.8	
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.5	3.8	121	ND	0.6	0.8	0.7	1.7	2.1	0.5	4.1	7.7	2.3	
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.4	2.8	137	0.3	0.7	1.0	0.8	2.1	2.7	0.6	4.5	9.2	2.6	
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	10.4	2.5	326	0.3	3.5	3.2	2.5	5.7	8.0	2.9	17.1	30.1	7.8	
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9.9	2.2	276	0.3	2.7	2.4	2.0	4.4	5.8	2.2	13.8	23.0	5.8	
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8.4	2.1	262	0.3	2.6	2.4	1.9	4.4	6.0	2.2	12.5	23.4	8.0	
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.2	3.0	54	ND	0.8	0.7	0.5	0.7	1.4	0.4	2.4	3.5	0.9	
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9.5	3.1	58	ND	0.7	0.7	0.5	1.3	1.6	0.5	2.8	4.7	1.4	
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.1	3.6	67	0.2	1.4	1.1	0.9	1.0	1.8	0.6	3.0	4.3	1.2	
5/1/00	South Bay Bndges	Shiner Surfperch	WB	20	12.6	2.4	174	0.3	2.1	1.8	1.4	2.0	3.0	0.9	6.0	10.7	2.9	
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	12.5	2.6	133	0.4	1.4	1.3	1.0	1.5	2.0	0.6	4.7	7.7	2.4	
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11.0	2.0	185	1.2	5.2	4.1	3.8	2.5	3.3	1.2	6.2	10.2	3.9	
5/24/00	Berkeley	Striped Bass	Off	3	51.0	0.8	53	ND	0.6	0.3	0.3	0.6	0.9	0.4	1.8	3.0	0.6	
5/25/00	Berkeley	Striped Bass	Off	3	51.7	0.7	60	ND	0.7	0.5	0.3	1.0	1.1	0.8	2.0	3.4	0.8	
5/26/00	Berkeley	Striped Bass	Off	3	67.0	1.4	75	ND	1.3	0.9	0.6	1.2	1.8	0.8	2.2	4.7	1.1	
6/2/00	San Pablo Bay	Striped Bass	Off	3	51.3	1.3	38	ND	0.4	ND	ND	0.8	0.7	0.4	1.3	2.3	0.5	
6/2/00	San Pablo Bay	Striped Bass	Off	3	53.0	1.1	27	ND	0.4	ND	ND	0.5	0.6	0.3	1.0	1.9	0.4	
6/2/00	San Pablo Bay	Striped Bass	Off	3	52.7	1.5	34	ND	0.5	0.3	ND	0.5	0.8	0.4	1.2	2.1	0.6	
6/2/00	San Pablo Bay	Striped Bass	Off	3	65.7	1.1	24	ND	0.4	0.2	ND	0.5	0.6	0.3	0.9	1.6	0.5	
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.7	1.2	51	ND	0.7	ND	ND	0.3	ND	ND	2.6	0.4	0.7	
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.0	1.2	34	ND	0.4	0.2	ND	0.5	0.7	0.4	1.2	2.1	0.5	
5/18/00	South Bay Bridges	Striped Bass	Off	3	50.0	1.0	34	ND	0.5	0.3	ND	0.6	0.8	0.4	1.3	2.2	0.5	
5/24/00	Berkeley	White Croaker	On	5	27.8	2.3	191	0.3	1.7	0.6	0.8	2.2	3.1	1.5	5.8	9.5	2.3	
5/24/00	Berkeley	White Croaker	On	5	26.4	2.7	100	0.2	1.2	0.6	0.8	1.3	2.0	0.9	3.2	5.5	1.4	
5/24/00	Berkeley	White Croaker	On	5	27.4	3.0	128	ND	1.2	0.7	0.5	1.5	2.1	1.0	3.8	6.4	1.8	
6/16/00	Oakland	White Croaker	On	5	24.0	4.8	281	0.5	3.8	2.0	1.9	4.4	7.3	3.4	10.1	19.2	4.2	
6/20/00	Oakland	White Croaker	On	5	24.8	6.3	196	0.4	2.6	1.9	1.3	2.9	5.2	2.3	7.1	13.0	2.9	
6/20/00	Oakland	White Croaker	On	5	27.4	5.7	354	0.6	4.6	b,e 2.5	2.3	5.8	8.9	4.2	13.3	b 26.0	5.3	
3/8/00	Oakland	White Croaker	On	5	25.2	1.9	134	0.2	1.9	b,e 1.3	0.9	2.0	3.3	1.4	4.5	b 8.2	1.8	
3/6/00	Oakland	White Croaker	On	5	23.6	1.0	61	ND	0.7	B,e	0.3	0.7	1.3	0.6	1.9	b 3.3	0.8	
3/8/00	Oakland	White Croaker	On	5	24.8	1.8	149	0.7	1.8	b,e 1.4	0.9	1.9	3.6	1.6	4.8	b 9.0	2.1	
9/26/00	Oakland	White Croaker	On	5	25.4	6.0	367	1.5	5.4	b 3.1	2.6	6.2	10.8	4.8	14.7	b 27.2	11.5	
9/26/00	Oakland	White Croaker	On	5	25.6	7.3	313	1.3	3.8	b 2.2	1.8	4.2	7.2	3.2	12.0	b 20.4	9.2	
9/26/00	Oakland	White Croaker	On	5	26.0	5.5	263	0.5	3.3	b,e 1.9	1.6	3.6	6.5	2.8	9.9	b 16.9	3.6	
12/18/00	Oakland	White Croaker	On	5	23.8	6.3	324	0.7	4.7	b 3.4	2.3	5.1	10.1	4.1	12.1	b 23.1	5.2	
12/18/00	Oakland	White Croaker	On	4	25.5	4.1	186	0.8	2.4	b,e 1.6	1.3	2.7	4.5	2.1	6.7	b 12.3	2.6	
12/18/00	Oakland	White Croaker	On	5	23.4	4.9	190	1.0	2.5	b,e 1.7	1.3	2.6	5.1	2.2	8.9	b 12.6	2.8	
5/3/00	S F Waterfront	White Croaker	On	5	27.6	2.0	158	ND	1.7	b,e 0.8	0.8	2.0	3.5	1.5	5.2	b 9.3	2.0	
5/3/00	S F Waterfront	White Croaker	On	5	26.6	1.8	179	0.2	1.8	b,e 0.8	0.9	2.3	3.7	1.7	5.9	b 11.1	2.3	
5/3/00	S F Waterfront	White Croaker	On	5	24.8	2.2	126	ND	1.3	0.7	0.7	1.7	2.8	1.2	4.0	7.1	1.7	
6/6/00	San Pablo Bay	White Croaker	On	5	28.0	4.9	254	0.3	2.3	1.2	1.0	2.7	4.5	1.9	6.7	13.6	2.5	
6/6/00	San Pablo Bay	White Croaker	On	5	28.6	5.3	220	ND	2.5	1.2	1.2	2.8	4.5	2.1	8.0	12.9	3.0	
6/2/00	San Pablo Bay	White Croaker																

Appendix Table 2b. PCB concentrations in fish, crab, and clam tissue samples, 1998-2000 (continued).

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Average Length		Sum of PCBs (SFEI)	PCB Congeners											
					cm	% Lipids		PCB 110	PCB 118	PCB 128	PCB 138	PCB 141	PCB 149	PCB 151	PCB 153	PCB 156	PCB 158		
																		ng/g	ng/g
5/3/00	S F Waterfront	California Halibut	Off	3	67.0	0.4	28	1.1	1.4	0.4	4.1	0.4	1.4	0.9	5.1	0.2	0.3		
5/4/00	S F Waterfront	California Halibut	Off	3	91.3	0.3	17	0.6	0.9	ND	2.4	0.2	1.0	0.5	2.9	ND	ND		
6/2/00	San Pablo Bay	California Halibut	Off	3	63.7	0.4	22	b,e 0.9	1.2	0.3	2.9	0.3	1.2	0.7	3.7	ND	0.2		
5/24/00	Berkeley	Jacksnail	WB	5	26.0	2.6	9	0.6	0.7	ND	1.3	ND	0.7	0.2	1.8	ND	ND		
6/14/00	Berkeley	Jacksnail	WB	5	26.6	2.5	17	0.8	1.0	0.2	2.2	ND	1.1	0.4	2.9	ND	ND		
6/15/00	Berkeley	Jacksnail	WB	5	27.4	3.0	10	0.7	0.9	ND	1.5	ND	0.7	0.3	1.6	ND	ND		
6/21/00	Oakland	Jacksnail	WB	5	26.8	1.5	105	b5.0	b6.2	1.4	13.6	1.0	6.7	2.9	18.1	0.8	1.1		
6/21/00	Oakland	Jacksnail	WB	5	27.4	2.3	51	b2.7	b3.3	0.7	6.5	0.4	3.3	1.5	8.3	ND	0.5		
6/22/00	Oakland	Jacksnail	WB	5	27.0	2.1	38	b,e 2.4	b2.4	0.4	4.4	0.3	2.5	1.0	5.2	ND	0.4		
5/3/00	S F Waterfront	Jacksnail	WB	5	25.8	1.0	20	1.1	1.2	0.3	2.7	0.2	1.6	0.8	3.2	ND	ND		
5/4/00	S F Waterfront	Jacksnail	WB	5	26.4	1.0	26	1.2	1.5	0.4	3.5	0.3	1.8	0.8	4.5	ND	0.2		
5/4/00	S F Waterfront	Jacksnail	WB	5	26.6	1.4	32	1.4	1.8	0.4	4.5	0.3	2.1	0.9	5.8	ND	0.3		
6/2/00	San Pablo Bay	Jacksnail	WB	5	27.2	0.8	34	1.4	1.6	0.5	4.6	0.3	2.1	1.0	6.5	ND	0.4		
6/2/00	San Pablo Bay	Jacksnail	WB	5	27.6	0.6	28	1.1	1.3	0.4	3.6	0.2	1.6	0.8	5.0	ND	0.3		
6/2/00	San Pablo Bay	Jacksnail	WB	5	27.0	0.7	35	1.3	1.8	0.6	4.9	0.3	2.1	1.0	6.7	ND	0.3		
5/1/00	South Bay Bridges	Jacksnail	WB	5	28.4	1.2	57	1.8	2.4	0.7	6.5	0.7	3.8	1.5	8.7	0.3	0.5		
5/1/00	South Bay Bridges	Jacksnail	WB	5	27.8	1.2	79	1.9	4.3	1.4	11.1	0.5	4.0	1.4	18.1	0.4	0.8		
5/1/00	South Bay Bridges	Jacksnail	WB	5	27.4	1.4	49	1.5	2.1	0.6	5.4	0.6	3.3	1.3	7.5	ND	0.5		
5/24/00	Berkeley	Leopard Shark	Off	3	92.3	0.4	5	ND	0.5	ND	1.1	ND	ND	ND	1.7	ND	ND		
5/25/00	Berkeley	Leopard Shark	Off	3	107.3	0.4	18	ND	1.3	0.2	3.5	ND	ND	ND	5.8	ND	0.3		
6/7/00	San Pablo Bay	Leopard Shark	Off	3	91.3	0.7	8	ND	0.6	ND	1.8	ND	ND	ND	2.7	ND	ND		
6/6/00	San Pablo Bay	Leopard Shark	Off	3	104.0	0.4	5	ND	0.5	ND	1.1	ND	ND	ND	1.7	ND	ND		
5/16/00	South Bay Bridges	Leopard Shark	Off	3	126.3	0.4	43	1.6	2.0	0.7	5.2	0.5	2.8	1.2	7.8	0.3	0.4		
5/16/00	South Bay Bridges	Leopard Shark	Off	3	96.7	0.4	20	ND	1.5	0.3	3.6	ND	0.2	ND	5.5	ND	0.3		
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.2	4.1	85	3.8	4.7	1.1	11.3	0.8	3.7	2.5	14.5	0.8	0.9		
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.5	3.8	103	3.1	5.7	1.4	14.8	1.0	4.0	3.0	18.9	0.8	1.1		
5/5/00	Berkeley	Shiner Surfperch	WB	20	13.1	3.6	100	3.6	5.9	1.4	13.8	1.0	4.0	2.7	17.3	0.8	1.1		
6/21/00	Oakland	Shiner Surfperch	WB	20	11.6	1.1	228	b7.8	b16.7	3.3	35.6	2.6	7.7	5.9	34.8	1.9	2.6		
6/16/00	Oakland	Shiner Surfperch	WB	20	12.1	1.3	282	b7.8	b19.7	4.2	44.3	3.3	9.8	7.5	39.5	2.2	3.1		
6/22/00	Oakland	Shiner Surfperch	WB	19	11.4	0.8	212	b6.7	b14.2	3.0	32.0	2.4	6.9	5.6	39.2	1.9	2.3		
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.3	2.6	102	3.3	5.8	1.1	14.3	1.4	4.3	3.1	18.7	0.8	1.2		
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.5	3.8	121	4.8	7.1	1.4	17.1	1.4	4.6	3.8	22.7	1.0	1.4		
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.4	2.8	137	4.6	8.1	1.6	19.8	1.7	5.4	4.1	25.2	1.1	1.6		
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	10.4	2.5	328	b16.2	29.2	5.2	46.8	3.2	14.7	8.0	44.4	2.7	3.6		
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9.9	2.2	276	b12.3	24.8	4.4	41.7	2.5	10.9	6.8	41.8	2.4	3.0		
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8.4	2.1	262	12.3	22.4	4.1	38.2	2.6	10.9	6.5	37.4	2.2	2.9		
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.2	3.0	54	2.2	2.9	0.8	7.1	0.4	2.5	1.4	9.2	0.4	0.6		
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9.5	3.1	58	2.5	3.9	1.0	7.8	0.5	2.7	1.4	8.9	0.4	0.6		
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.1	3.6	67	2.9	3.6	1.0	8.1	0.5	3.2	1.7	10.1	0.4	0.6		
5/1/00	South Bay Bndges	Shiner Surfperch	WB	20	12.8	2.4	174	4.9	8.8	2.4	24.4	2.0	6.9	5.0	31.6	1.3	1.7		
5/1/00	South Bay Bndges	Shiner Surfperch	WB	20	12.5	2.6	133	3.4	7.0	1.9	18.5	1.3	4.6	3.7	25.3	1.0	1.4		
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11.0	2.0	165	4.4	10.3	2.0	19.3	1.3	4.7	3.4	23.7	1.1	1.5		
5/24/00	Berkeley	Striped Bass	Off	3	51.0	0.6	53	2.0	2.1	0.6	8.4	0.9	3.1	1.7	8.0	0.3	0.5		
5/25/00	Berkeley	Striped Bass	Off	3	51.7	0.7	60	2.7	2.8	0.9	7.4	0.7	3.5	1.7	10.3	0.4	0.6		
5/26/00	Berkeley	Striped Bass	Off	3	67.0	1.4	75	3.1	3.3	0.9	9.0	1.0	5.0	2.2	11.5	0.4	0.7		
6/2/00	San Pablo Bay	Striped Bass	Off	3	51.3	1.3	38	1.5	1.7	0.5	4.6	0.5	2.5	1.2	6.8	0.2	0.4		
6/2/00	San Pablo Bay	Striped Bass	Off	3	53.0	1.1	27	1.2	1.4	0.4	3.3	0.3	1.8	0.8	4.5	ND	0.2		
6/2/00	San Pablo Bay	Striped Bass	Off	3	52.7	1.5	34	b,e 1.6	1.8	0.5	4.3	0.4	2.2	1.1	5.8	0.2	0.3		
6/2/00	San Pablo Bay	Striped Bass	Off	3	65.7	1.1	24	b,e 1.3	1.4	0.4	3.0	0.3	1.6	0.8	3.8	ND	0.2		
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.7	1.2	51	ND	3.3	0.7	9.0	ND	0.4	ND	15.0	0.4	0.8		
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.0	1.2	34	1.5	1.8	0.5	4.1	0.4	2.3	1.0	5.9	0.2	0.3		
5/18/00	South Bay Bridges	Striped Bass	Off	3	50.0	1.0	34	1.6	1.7	0.5	4.1	0.4	2.3	1.0	5.6	ND	0.3		
5/24/00	Berkeley	White Croaker	On	5	27.6	2.3	191	6.5	8.2	2.7	26.9	2.3	12.1	5.3	33.7	1.0	1.8		
5/24/00	Berkeley	White Croaker	On	5	26.4	2.7	100	3.8	4.5	1.4	12.9	1.2	6.3	2.8	16.0	0.6	0.9		
5/24/00	Berkeley	White Croaker	On	5	27.4	3.0	128	4.6	5.5	1.8	17.7	1.6	8.0	3.6	21.8	0.7	1.2		
6/16/00	Oakland	White Croaker	On	5	24.0	4.6	281	13.3	14.5	4.2	39.5	3.9	20.0	7.5	35.8	1.9	2.7		
6/20/00	Oakland	White Croaker	On	5	24.8	6.3	186	8.2	8.9	2.6	25.3	2.6	13.9	5.5	30.7	1.2	1.7		
6/20/00	Oakland	White Croaker	On	5	27.4	5.7	354	b17.7	b19.1	5.1	49.2	4.7	25.4	10.2	44.0	2.0	3.3		
3/8/00	Oakland	White Croaker	On	5	25.2	1.9	134	b5.7	b6.2	1.8	16.4	1.6	8.5	3.8	20.4	0.9	1.2		
3/8/00	Oakland	White Croaker	On	5	23.6	1.0	81	b,e 2.4	b2.5	0.8	7.6	0.7	3.7	1.6	9.7	0.4	0.5		
3/8/00	Oakland	White Croaker	On	5	24.8	1.8	149	b6.3	b8.9	2.0	19.0	1.8	9.8	4.0	23.7	1.0	1.3		
9/26/00	Oakland	White Croaker	On	5	25.4	6.0	367	b10.4	b19.2	5.0	49.4	5.3	28.0	9.9	43.8	1.5	3.5		
9/28/00	Oakland	White Croaker	On	5	25.6	7.3	313	b8.7	b14.3	4.8	43.8	4.2	22.9	8.8	40.5	1.3	3.0		
9/26/00	Oakland	White Croaker	On	5	28.0	5.5	263	b8.5	b11.8	3.8	35.9	3.5	19.0	7.5	37.1	1.5	2.4		
12/18/00	Oakland	White Croaker	On	5	23.8	6.3	324	b12.4	b16.2	4.5	42.7	4.6	24.0	8.7	40.1	1.9	3.1		
12/18/00	Oakland	White Croaker	On	4	25.5	4.1	188	b7.3	b8.9	2.6	24.3	2.4	12.8	5.1	29.9	1.1	1.7		
12/18/00	Oakland	White Croaker	On	5	23.4	4.9	190	b8.1	b8.8	2.6	24.4	2.5	13.0	5.3	29.3	1.2	1.7		
5/3/00	S F Waterfront	White Croaker	On	5	27.8	2.0	156	b6.7	b7.3	2.0	20.2	2.0	10.3	4.7	25.4	1.1	1.4		
5/3/00	S F Waterfront	White Croaker	On	5	26.6	1.8	179	b7.6	b8.4	2.	23.9	2.3	12.3	5.3	30.1	1.2	1.7		
5/3/00	S F Waterfront	White Croaker	On	5	24.8	2.2	126	5.4	6.0	1.7	16.5	1.6	8.6	3.7	20.3	0.9	1.2		
6/8/00	San Pablo Bay	White Croaker	On	5	28.0	4.9	254	9.3	10.2	3.5	36.7	2.8	16.4	7.8	38.7	1.5	2.3		
6/8/00	San Pablo Bay	White Croaker	On	5	26.6	5.3	220	8.6	9.9	3.4	30.1	2.7	11.7	6.8	35.2	1.5	2.0		
6/2/00	San Pablo Bay	White Croaker	On	5	28.0	4.4	169	6.6	7.1	2.5	23.0	1.9	11.2	4.9	29.3	0.9	1.5		
5/1/00	South Bay Bndges	White Croaker	On	5	27.8	2.8	229	7.5	10.3	3.8	35.8	2.7	14.6	6.7	30.5	1.2	2.2		
5/1/00	South Bay Bndges	White Croaker	On	5	28.4	4.4	171	7.0	8.2	2.6	22.8	1.9	10.9	4.6	28.0	1.1	1.5		
5/1/00	South Bay Bndges	White Croaker	On	5	27.8	4.0	205	8.7	8.5	2.9	27.1	2.4	13.5	5.5	35.4	1.3	1.7		
3/21/00	San Pablo Bay	White Sturgeon	Off	3	119.8	0.6	20	b,e 1.1	0.5	0.7	3.1	0.2	1.3	0.6	3.6	ND	0.2		
3/23/00	San Pablo Bay	White Sturgeon	Off	3	143.0	1.8	54	b3.25	1.3	0.7	7.6	0.4	4.8	2.1	8.4	0.3	0.5		
4/19/00	South Bay Bridges	White Sturgeon	Off	3	124.3														

Appendix Table 2b. PCB concentrations in fish, crab, and clam tissue samples, 1998-2000 (continued).

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Average Length	% Lipids	Sum of PCBs (SFEI)	PCB 170	PCB 174	PCB 177	PCB 180	PCB 183	PCB 187	PCB 194	PCB 195	PCB 201	PCB 203
					cm	%	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
5/3/00	S F Waterfront	California Halibut	Off	3	67.0	0.4	28	0.8	0.3	0.8	2.4	0.8	2.3	0.4	ND	0.5	0.3
5/4/00	S F Waterfront	California Halibut	Off	3	91.3	0.3	17	0.5	0.2	0.5	1.4	0.5	1.5	0.2	ND	0.4	ND
6/2/00	San Pablo Bay	California Halibut	Off	3	63.7	0.4	22	0.6	0.2	0.7	1.7	0.6	1.8	0.2	ND	0.4	0.2
5/24/00	Berkeley	Jacksmelt	WB	5	26.0	2.6	9	0.2	ND	0.2	0.6	0.2	0.6	ND	ND	ND	ND
6/14/00	Berkeley	Jacksmelt	WB	5	26.6	2.5	17	0.5	0.2	0.3	1.4	0.4	0.9	0.3	ND	0.2	ND
6/15/00	Berkeley	Jacksmelt	WB	5	27.4	3.0	10	ND	ND	ND	0.5	ND	0.5	ND	ND	ND	ND
6/21/00	Oakland	Jacksmelt	WB	5	26.8	1.5	105	1.6	1.2	1.8	5.0	2.4	5.3	0.6	0.3	0.8	0.5
6/21/00	Oakland	Jacksmelt	WB	5	27.4	2.3	51	0.7	0.5	1.0	2.0	1.1	2.7	0.3	ND	0.5	ND
6/22/00	Oakland	Jacksmelt	WB	5	27.0	2.1	38	0.5	0.4	0.6	1.4	0.7	1.7	ND	ND	0.3	ND
5/3/00	S F Waterfront	Jacksmelt	WB	5	25.8	1.0	20	0.4	0.3	0.4	1.1	0.4	1.2	ND	ND	0.3	ND
5/4/00	S F Waterfront	Jacksmelt	WB	5	26.4	1.0	26	0.6	0.4	0.6	1.5	0.6	1.8	0.3	ND	0.4	ND
5/4/00	S F Waterfront	Jacksmelt	WB	5	28.6	1.4	32	0.7	0.5	0.8	1.7	0.8	2.2	0.3	ND	0.5	ND
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.2	0.8	34	0.7	0.5	1.0	2.0	1.0	2.8	0.3	ND	0.6	0.2
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.6	0.6	26	0.5	0.3	0.7	1.5	0.7	2.1	0.2	ND	0.5	ND
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.0	0.7	35	0.8	0.4	0.9	2.0	1.0	2.7	0.3	ND	0.6	ND
5/1/00	South Bay Bridges	Jacksmelt	WB	5	28.4	1.2	57	e11	1.0	1.4	3.3	1.4	3.8	0.5	0.2	0.9	0.5
5/1/00	South Bay Bridges	Jacksmelt	WB	5	27.8	1.2	79	e18	0.9	1.5	4.6	2.2	5.8	0.8	0.3	1.2	0.4
5/1/00	South Bay Bridges	Jacksmelt	WB	5	27.4	1.4	49	e0.9	0.8	1.2	2.7	1.2	3.1	0.4	0.2	0.8	0.4
5/24/00	Berkeley	Leopard Shark	Off	3	92.3	0.4	5	0.2	ND	ND	0.7	0.2	0.3	ND	ND	ND	ND
5/25/00	Berkeley	Leopard Shark	Off	3	107.3	0.4	18	0.7	ND	ND	2.3	0.8	0.9	0.3	ND	ND	0.2
6/7/00	San Pablo Bay	Leopard Shark	Off	3	91.3	0.7	8	0.3	ND	ND	0.9	0.4	0.6	ND	ND	ND	ND
6/6/00	San Pablo Bay	Leopard Shark	Off	3	104.0	0.4	5	ND	ND	ND	0.6	0.2	0.4	ND	ND	ND	ND
5/16/00	South Bay Bridges	Leopard Shark	Off	3	126.3	0.4	43	e10	0.7	1.1	3.0	1.2	3.4	0.5	ND	0.7	0.3
5/16/00	South Bay Bridges	Leopard Shark	Off	3	96.7	0.4	20	e0.8	ND	ND	2.1	0.8	1.6	0.4	ND	0.4	0.2
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.2	4.1	85	2.2	0.4	2.2	6.3	2.1	5.7	0.9	0.3	1.1	0.6
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.5	3.6	103	2.9	0.5	2.8	8.4	2.8	7.6	1.1	0.4	1.4	0.8
5/5/00	Berkeley	Shiner Surfperch	WB	20	13.1	3.6	100	2.8	0.5	2.5	7.4	2.5	6.6	1.0	0.3	1.2	0.7
6/21/00	Oakland	Shiner Surfperch	WB	20	11.6	1.1	228	5.9	0.8	4.3	16.7	5.3	13.3	2.2	0.9	2.2	2.1
6/16/00	Oakland	Shiner Surfperch	WB	20	12.1	1.3	282	7.8	1.1	5.5	22.4	8.9	16.9	2.8	1.1	2.6	2.5
6/22/00	Oakland	Shiner Surfperch	WB	19	11.4	0.8	212	5.4	0.7	4.1	15.8	5.0	12.4	2.0	0.8	2.1	1.9
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.3	2.6	102	3.1	0.5	2.4	8.5	2.7	8.4	1.1	0.4	1.1	0.8
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.5	3.8	121	3.5	0.5	2.8	10.1	3.1	7.9	1.3	0.5	1.4	0.9
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.4	2.8	137	4.0	0.5	3.1	11.4	3.5	8.5	1.4	0.5	1.4	1.0
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	10.4	2.5	328	5.9	1.1	5.4	16.6	5.8	15.6	1.9	0.8	1.9	1.8
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9.9	2.2	276	5.6	0.8	4.8	15.2	5.0	14.3	1.8	0.8	1.7	1.6
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8.4	2.1	262	5.5	0.8	4.6	14.9	4.8	13.2	1.8	0.8	1.7	1.6
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.2	3.0	54	0.8	0.2	1.3	2.9	1.3	3.7	0.4	ND	0.6	0.3
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9.5	3.1	58	1.0	0.3	1.3	2.8	1.2	3.4	0.3	ND	0.5	0.3
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.1	3.6	67	1.1	0.4	1.5	3.2	1.5	4.1	0.4	ND	0.7	0.4
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	12.6	2.4	174	e4.5	0.8	4.3	13.2	4.5	12.8	1.9	0.7	2.2	1.4
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	12.5	2.6	133	e3.7	0.6	3.3	10.4	3.6	10.2	1.4	0.5	1.7	1.1
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11.0	2.0	185	e3.1	0.5	2.9	8.5	3.2	8.8	1.2	0.4	1.5	1.0
5/24/00	Berkeley	Striped Bass	Off	3	51.0	0.8	53	1.6	0.9	1.4	4.5	1.4	4.3	0.8	0.3	1.1	0.6
5/25/00	Berkeley	Striped Bass	Off	3	51.7	0.7	60	1.4	0.8	1.4	4.3	1.6	4.7	0.6	0.2	1.0	0.5
5/26/00	Berkeley	Striped Bass	Off	3	67.0	1.4	75	1.5	1.1	1.7	4.8	1.9	4.9	0.7	0.3	1.1	0.8
6/2/00	San Pablo Bay	Striped Bass	Off	3	51.3	1.3	38	0.8	0.5	1.0	2.7	1.0	3.0	0.4	ND	0.6	0.3
6/2/00	San Pablo Bay	Striped Bass	Off	3	53.0	1.1	27	0.6	0.4	0.7	1.8	0.7	2.0	0.3	ND	0.4	0.2
6/2/00	San Pablo Bay	Striped Bass	Off	3	52.7	1.5	34	0.7	0.4	0.8	2.3	0.9	2.4	0.3	ND	0.5	0.3
6/2/00	San Pablo Bay	Striped Bass	Off	3	65.7	1.1	24	0.5	0.3	0.5	1.5	0.6	1.6	0.2	ND	0.3	ND
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.7	1.2	51	e2.0	ND	0.3	5.6	2.2	4.0	0.7	0.3	0.8	0.5
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.0	1.2	34	e0.8	0.6	0.9	2.4	0.9	2.6	0.4	ND	0.6	0.3
5/18/00	South Bay Bridges	Striped Bass	Off	3	50.0	1.0	34	e0.7	0.5	0.8	2.2	0.9	2.5	0.3	ND	0.5	0.3
5/24/00	Berkeley	White Croaker	On	5	27.6	2.3	191	5.2	3.5	5.3	16.2	5.3	15.3	2.3	0.7	3.3	1.6
5/24/00	Berkeley	White Croaker	On	5	26.4	2.7	100	2.4	1.8	2.5	8.0	2.5	7.4	1.3	0.4	1.7	0.9
5/24/00	Berkeley	White Croaker	On	5	27.4	3.0	128	3.2	2.2	3.6	10.7	3.5	10.3	1.6	0.5	2.3	1.1
6/16/00	Oakland	White Croaker	On	5	24.0	4.8	281	e6.3	4.8	8.0	19.8	6.4	17.2	2.8	1.1	3.5	2.2
6/20/00	Oakland	White Croaker	On	5	24.8	6.3	198	e4.2	3.4	4.4	12.8	4.5	12.3	1.7	0.7	2.4	1.3
6/20/00	Oakland	White Croaker	On	5	27.4	5.7	354	7.5	5.8	7.4	23.8	7.9	22.0	3.1	1.2	4.1	2.5
3/8/00	Oakland	White Croaker	On	5	25.2	1.9	134	3.0	2.4	3.3	9.4	3.2	9.3	1.4	0.5	2.1	1.1
3/8/00	Oakland	White Croaker	On	5	23.6	1.0	81	1.5	1.2	1.8	4.7	1.7	5.0	0.9	0.3	1.2	0.6
9/26/00	Oakland	White Croaker	On	5	24.8	1.8	149	3.5	2.6	3.6	10.8	3.6	10.1	1.8	0.6	2.2	1.3
9/26/00	Oakland	White Croaker	On	5	25.4	6.0	367	7.8	6.4	7.2	24.0	7.8	21.2	3.1	1.2	4.1	2.6
9/26/00	Oakland	White Croaker	On	5	25.6	7.3	313	7.5	5.7	7.4	23.4	7.9	22.1	3.0	1.0	4.1	2.2
12/18/00	Oakland	White Croaker	On	5	26.0	5.5	263	6.2	4.8	6.4	19.3	6.4	18.8	2.5	0.9	3.6	1.8
12/18/00	Oakland	White Croaker	On	5	23.8	6.3	324	7.1	5.7	6.4	21.9	6.9	18.3	2.8	1.1	3.6	2.2
12/18/00	Oakland	White Croaker	On	4	25.5	4.1	186	4.1	3.0	4.0	11.9	4.3	11.5	1.7	0.6	2.2	1.3
12/18/00	Oakland	White Croaker	On	5	23.4	4.9	190	4.2	3.3	4.2	12.3	4.2	11.4	1.7	0.6	2.3	1.2
5/3/00	S F Waterfront	White Croaker	On	5	27.6	2.0	156	3.8	2.8	3.7	12.0	3.9	11.2	1.9	0.6	2.6	1.4
5/3/00	S F Waterfront	White Croaker	On	5	26.6	1.8	179	4.2	3.2	4.2	13.1	4.3	12.1	1.9	0.7	2.6	1.4
5/3/00	S F Waterfront	White Croaker	On	5	24.8	2.2	126	3.0	2.3	3.1	9.8	3.1	9.0	1.8	0.5	2.2	1.2
6/8/00	San Pablo Bay	White Croaker	On	5	28.0	4.9	254	6.1	3.9	7.1	21.1	7.6	23.5	2.7	1.0	4.4	2.4
6/8/00	San Pablo Bay	White Croaker	On	5	28.6	5.3	220	5.9	3.9	5.9	16.1	5.8	17.2	2.2	0.8	3.4	1.7
6/2/00	San Pablo Bay	White Croaker	On	5	28.0	4.4	169	3.8	2.8	4.4	12.1	4.4	13.5	1.6	0.6	2.7	1.3
5/1/00	South Bay Bridges	White Croaker	On	5	27.8	2.8	229	e5.9	3.7	8.5	19.1	6.8	21.7	2.8	0.9	3.8	2.0
5/1/00	South Bay Bridges	White Croaker	On	5	26.4	4.4	171	e3.7	2.7	4.2	10.9	4.0	12.4	1.6	0.6	2.4	1.2
5/1/00	South Bay Bridges	White Croaker	On	5	27.8	4.0	205	e4.7	3.5	5.3	15.1	5.3	16.3	2.2	0.8	3.3	1.7
3/21/00	San Pablo Bay	White Sturgeon	Off	3	119.0	0.6	20	0.4	0.3	0.6	1.4	0.6	1.5	0.2	ND	0.3	ND
3/22/00	San Pablo Bay	White Sturgeon	Off	3	143.0	1.8	54	0.7	0.4	1.9	2.2	1.4	4.5	0.3	ND	0.4	0.2
4/19/00	South Bay Bridges	White Sturgeon	Off	3	124.3	0.5	31	e0.6	0.5	1.1	2.0	0.9	2.8	0.4	ND	0.5	0.3
4/19/00	South Bay Bridges	White Sturgeon	Off	3	155.3	0.6	55	e0.9	0.6	1.7	3.4	1.6	4.9	0.6	ND	0.7	0.4
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	12.3	0											

Appendix Table 2c. Pesticide concentrations in fish, crab, and clam tissue samples, 1998-2000.

Sample ID	Fish ID	Date	Station	Fish Species	Tissue Analyzed	% Homogenized	Range of Lengths (cm)	Average Length (cm)	% Lipids	% Moisture	Total DDTs (SFEI)	p,p'-DDD	p,p'-DDE	p,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	p,p'-DDMU
C003801	134	5/3/00	S F Waterfront	California Halibut	Off	3	65-84, 82	67.0	0.4	74.4	7.7	ND	ND	ND	ND	ND	ND	ND
C003802	135	5/4/00	S F Waterfront	California Halibut	Off	3	84-92, 88	91.3	0.3	78.1	4.9	ND	ND	ND	ND	ND	ND	ND
C005801	167	8/2/00	San Pablo Bay	California Halibut	Off	3	55-81, 75	83.7	0.4	77.3	6.0	ND	ND	ND	ND	ND	ND	ND
C004301	142	5/24/00	Berkeley	Jacksmelt	WB	5	24-28	26.0	2.6	74.8	18.1	ND	ND	ND	ND	ND	ND	ND
C004302	143	9/14/00	Berkeley	Jacksmelt	WB	5	25-28	26.6	2.5	73.7	18.4	ND	ND	ND	ND	ND	ND	ND
C004303	144	8/15/00	Berkeley	Jacksmelt	WB	5	26-28	27.4	3.0	73.8	32.1	ND	ND	ND	ND	ND	ND	ND
C002301	121	8/21/00	Oakland	Jacksmelt	WB	5	25-30	26.8	1.5	74.8	19.8	ND	ND	ND	ND	ND	ND	ND
C002302	122	8/21/00	Oakland	Jacksmelt	WB	5	26-29	27.4	2.3	75.2	17.9	ND	ND	ND	ND	ND	ND	ND
C002303	123	8/22/00	Oakland	Jacksmelt	WB	5	25-29	27.0	2.1	74.8	13.7	ND	ND	ND	ND	ND	ND	ND
C003301	131	5/3/00	S F Waterfront	Jacksmelt	WB	5	24-27	25.8	1.0	76.5	21.8	ND	ND	ND	ND	ND	ND	ND
C003302	132	5/4/00	S F Waterfront	Jacksmelt	WB	5	25-28	26.4	1.0	76.8	20.5	ND	ND	ND	ND	ND	ND	ND
C003303	133	5/4/00	S F Waterfront	Jacksmelt	WB	5	25-28	26.6	1.4	75.7	30.6	ND	ND	ND	ND	ND	ND	ND
C005301	157	8/2/00	San Pablo Bay	Jacksmelt	WB	5	26-28	27.2	0.8	76.2	20.4	ND	ND	ND	ND	ND	ND	ND
C005302	158	8/2/00	San Pablo Bay	Jacksmelt	WB	5	27-28	27.6	0.8	77.9	20.5	ND	ND	ND	ND	ND	ND	ND
C005303	159	8/2/00	San Pablo Bay	Jacksmelt	WB	5	25-29	27.0	0.7	77.2	28.3	ND	ND	ND	ND	ND	ND	ND
C001301	94	5/1/00	South Bay Bridges	Jacksmelt	WB	5	24-28	26.4	1.2	76.4	19.6	ND	ND	ND	ND	ND	ND	ND
C001302	95	5/1/00	South Bay Bridges	Jacksmelt	WB	5	27-28	27.8	1.2	76.6	26.4	ND	ND	ND	ND	ND	ND	ND
C001303	96	5/1/00	South Bay Bridges	Jacksmelt	WB	5	26-29	27.4	1.4	76.5	28.5	ND	ND	ND	ND	ND	ND	ND
C004402	146	5/24/00	Berkeley	Leopard Shark	Off	3	82-92, 93	92.3	0.4	77	ND	ND	ND	ND	ND	ND	ND	ND
C004403	147	5/25/00	Berkeley	Leopard Shark	Off	3	99-110, 113	107.3	0.4	77.2	6.0	ND	ND	ND	ND	ND	ND	ND
C005403	182	8/6/00	San Pablo Bay	Leopard Shark	Off	3	98-107	104.0	0.4	77.3	3.1	ND	ND	ND	ND	ND	ND	ND
C005402	181	8/7/00	San Pablo Bay	Leopard Shark	Off	3	90-91, 93	91.3	0.7	76.6	4.3	ND	ND	ND	ND	ND	ND	ND
C001404	100	5/16/00	South Bay Bridges	Leopard Shark	Off	3	120-125, 134	126.3	0.4	77.5	15.5	ND	ND	ND	ND	ND	ND	ND
C001401	97	5/18/00	South Bay Bridges	Leopard Shark	Off	3	82-88, 100	88.7	0.4	78	5.9	ND	ND	ND	ND	ND	ND	ND
C004501	148	5/24/00	Berkeley	Striped Bass	Off	3	48-51, 54	51.0	0.8	77.7	18.7	ND	ND	ND	ND	ND	ND	ND
C004502	149	5/25/00	Berkeley	Striped Bass	Off	3	51-51, 53	51.7	0.7	77.8	38.9	ND	ND	ND	ND	ND	ND	ND
C004503	150	5/26/00	Berkeley	Striped Bass	Off	3	61-62, 78	67.0	1.4	76.7	31.0	ND	ND	ND	ND	ND	ND	ND
C005501	183	8/2/00	San Pablo Bay	Striped Bass	Off	3	45-51, 58	51.3	1.3	77.2	24.5	ND	ND	ND	ND	ND	ND	ND
C005502	184	8/2/00	San Pablo Bay	Striped Bass	Off	3	50-54, 55	53.0	1.1	76.5	16.0	ND	ND	ND	ND	ND	ND	ND
C005503	185	8/2/00	San Pablo Bay	Striped Bass	Off	3	50-51, 57	52.7	1.5	75.5	18.5	ND	ND	ND	ND	ND	ND	ND
C005504	186	8/2/00	San Pablo Bay	Striped Bass	Off	3	60-62, 75	65.7	1.1	76	25.2	ND	ND	ND	ND	ND	ND	ND
C001501	101	5/1/00	South Bay Bridges	Striped Bass	Off	3	47-49, 50	48.4	1.2	77	22.1	ND	ND	ND	ND	ND	ND	ND
C001502	102	5/1/00	South Bay Bridges	Striped Bass	Off	3	45-47, 52	48.0	1.2	77.2	14.7	ND	ND	ND	ND	ND	ND	ND
C001503	103	5/18/00	South Bay Bridges	Striped Bass	Off	3	46-47, 57	50.0	1.0	77.8	27.0	ND	ND	ND	ND	ND	ND	ND
C004201	139	5/5/00	Berkeley	Shiner Surfperch	WB	20	11-13	12.2	4.1	75.8	38.3	ND	ND	ND	ND	ND	ND	ND
C004202	140	5/5/00	Berkeley	Shiner Surfperch	WB	20	11-14	12.5	3.8	76.6	40.9	ND	ND	ND	ND	ND	ND	ND
C004203	141	5/5/00	Berkeley	Shiner Surfperch	WB	20	11-15	13.1	3.6	76.1	48.6	2.1	ND	ND	ND	ND	ND	ND
C002202	119	8/15/00	Oakland	Shiner Surfperch	WB	20	11-15	12.1	1.3	76.6	49.6	ND	ND	ND	ND	ND	ND	ND
C002201	118	8/21/00	Oakland	Shiner Surfperch	WB	20	10-13	11.6	1.1	76	45.8	ND	ND	ND	ND	ND	ND	ND
C002203	120	8/22/00	Oakland	Shiner Surfperch	WB	18	10-14	11.4	0.8	79.9	30.1	ND	ND	ND	ND	ND	ND	ND
C003201	128	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10-14	11.3	2.6	77	25.0	ND	ND	ND	ND	ND	ND	ND
C003202	129	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10-13	11.5	3.8	75.8	34.0	ND	ND	ND	ND	ND	ND	ND
C003203	130	5/3/00	S F Waterfront	Shiner Surfperch	WB	20	10-13	11.4	2.8	76.3	33.3	ND	ND	ND	ND	ND	ND	ND
C008201	170	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9-12	10.4	2.5	77.4	45.3	2.6	ND	ND	ND	ND	ND	ND
C008202	171	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9-11	9.9	2.2	77.4	41.7	2.2	ND	ND	ND	ND	ND	ND
C008203	172	11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8-10	8.4	2.1	77.8	42.5	2.5	ND	ND	ND	ND	ND	ND
C005201	154	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	8-12	10.2	3.0	77.4	23.5	ND	ND	ND	ND	ND	ND	ND
C005202	155	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9-11	9.5	3.1	76.4	21.1	ND	ND	ND	ND	ND	ND	ND
C005203	156	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9-12	10.1	3.6	76.2	28.0	ND	ND	ND	ND	ND	ND	ND
C001201	91	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11-15	12.8	2.4	76.9	45.1	ND	ND	ND	ND	ND	ND	ND
C001202	92	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11-14	12.5	2.6	77.3	37.9	ND	ND	ND	ND	ND	ND	ND
C001203	93	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	10-14	11.0	2.0	77.8	33.4	ND	ND	ND	ND	ND	ND	ND
C005701	188	3/21/00	San Pablo Bay	White Sturgeon	Off	3	115-117, 125	118.0	0.6	76.6	7.9	ND	ND	ND	ND	ND	ND	ND
C005702	189	3/22/00	San Pablo Bay	White Sturgeon	Off	3	133-147, 149	143.0	1.8	78.2	31.6	ND	ND	ND	ND	ND	ND	ND
C001701	104	4/18/00	South Bay Bridges	White Sturgeon	Off	3	121-122, 123	124.3	0.5	79.7	9.8	ND	ND	ND	ND	ND	ND	ND
C001702	105	4/18/00	South Bay Bridges	White Sturgeon	Off	3	135-148, 182	155.3	0.8	77.7	15.2	ND	ND	ND	ND	ND	ND	ND
C004101	136	5/24/00	Berkeley	White Croaker	On	5	24-28	27.6	2.3	74.9	57.2	ND	ND	ND	ND	ND	ND	ND
C004102	137	5/24/00	Berkeley	White Croaker	On	5	24-28	26.4	2.7	76.1	31.8	ND	ND	ND	ND	ND	ND	ND
C004103	138	5/24/00	Berkeley	White Croaker	On	5	25-28	27.4	3.0	76.6	38.7	ND	ND	ND	ND	ND	ND	ND
C002104	109	3/8/00	Oakland	White Croaker	On	5	23-27	25.2	1.8	74.5	100.0	2.6	ND	ND	ND	ND	ND	ND
C002105	110	3/8/00	Oakland	White Croaker	On	5	22-25	23.6	1.0	76	20.4	ND	ND	ND	ND	ND	ND	ND
C002106	111	3/8/00	Oakland	White Croaker	On	5	21-28	24.6	1.8	75.7	33.7	ND	ND	ND	ND	ND	ND	ND
C002107	108	6/18/00	Oakland	White Croaker	On	5	21-28	24.0	4.8	74	73.2	ND	ND	ND	ND	ND	ND	ND
C002108	107	6/20/00	Oakland	White Croaker	On	5	22-28	24.8	6.3	74	62.1	ND	ND	ND	ND	ND	ND	ND
C002109	106	9/20/00	Oakland	White Croaker	On	5	24-29	27.4	5.7	73.8	84.2	ND	ND	ND	ND	ND	ND	ND
C002110	112	9/26/00	Oakland	White Croaker	On	5	22-29	25.4	6.0	73.2	80.3	ND	ND	ND	ND	ND	ND	ND
C002111	113	9/26/00	Oakland	White Croaker	On	5	22-30	25.6	7.3	72.6	61.3	ND	ND	ND	ND	ND	ND	ND
C002112	114	9/26/00	Oakland	White Croaker	On	5	21-30	26.0	5.5	73.1	73.3	ND	ND	ND	ND	ND	ND	ND
C002113	115	12/18/00	Oakland	White Croaker	On	5	21-30	23.8	6.3	73	62.1	ND	ND	ND	ND	ND	ND	ND
C002114	116	12/18/00	Oakland	White Croaker	On	4	22-29	25.5	4.1	74.1	46.1	ND	ND	ND	ND	ND	ND	ND
C002115	117	12/18/00	Oakland	White Croaker	On	5	21-27	23.4	4.8	73.9	51.4	ND	ND	ND	ND	ND	ND	ND
C003101	125	5/3/00	S F Waterfront	White Croaker	On	5	25-30	27.8	2.0	77.4	52.2	ND	ND	ND	ND	ND	ND	ND
C003102	126	5/3/00	S F Waterfront	White Croaker	On	5	25-28	26.8	1.8	77.8	51.1	ND	ND	ND	ND	ND	ND	ND
C003103	127	5/3/00	S F Waterfront	White Croaker	On	5	22-27	24.8	2.2	76.3	38.0	ND	ND	ND	ND	ND	ND	ND
C005103	153	8/2/00	San Pablo Bay	White Croaker	On	5	25-30	28.0	4.4	74.2	65.9	ND	ND	ND	ND	ND	ND	ND
C005101	151	8/8/00	San Pablo Bay	White Croaker	On	5	23-30	28.0	4.6	74.7	113.0	ND	ND	ND	ND	ND	ND	ND
C005102	152	8/8/00	San Pablo Bay	White Croaker	On	5	27-30	26.8	5.3	73.6	104.8	ND	ND	ND	ND	ND	ND	ND
C001101	88	5/1/00	South Bay Bridges	White Croaker	On	5	26-30	27.8	2.8	75.9	61.2	ND	ND	ND	ND	ND	ND	ND
C001102	89	5/1/00	South Bay Bridges	White Croaker	On	5	24-30	28.4	4.4	74.3	52.7	ND	ND	ND	ND	ND	ND	ND
C001103	90																	

Appendix Table 2c. Pesticide concentrations in fish, crab, and clam tissue samples, 1998-2000 (continued).

Date	Station	Fish Species	Tissue Analyzed	% Homogenized	Average Length cm	% Lipids	Total Chlordanes (SFEI)	alpha-Chlordane	gamma-Chlordane	delta-Nonachlor	trans-Nonachlor	Heptachlor	Heptachlor Epoxide	Orychlordane
5/3/00	S F Waterfront	California Halibut	Off	3	67.0	0.4	ND	ND	ND	ND	ND	ND	ND	ND
5/4/00	S F Waterfront	California Halibut	Off	3	91.3	0.3	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	California Halibut	Off	3	63.7	0.4	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	Jacksnail	WB	5	26.0	2.6	ND	ND	ND	ND	ND	ND	ND	ND
6/14/00	Berkeley	Jacksnail	WB	5	26.6	2.5	ND	ND	ND	ND	ND	ND	ND	ND
6/15/00	Berkeley	Jacksnail	WB	5	27.4	3.0	ND	ND	ND	ND	ND	ND	ND	ND
6/21/00	Oakland	Jacksnail	WB	5	26.8	1.5	2.5	ND	ND	ND	2.5	ND	ND	ND
6/21/00	Oakland	Jacksnail	WB	5	27.4	2.3	1.2	ND	ND	ND	1.2	ND	ND	ND
6/22/00	Oakland	Jacksnail	WB	5	27.0	2.1	1.3	ND	ND	ND	1.3	ND	ND	ND
5/3/00	S F Waterfront	Jacksnail	WB	5	25.8	1.0	ND	ND	ND	ND	ND	ND	ND	ND
5/4/00	S F Waterfront	Jacksnail	WB	5	26.4	1.0	ND	ND	ND	ND	ND	ND	ND	ND
5/4/00	S F Waterfront	Jacksnail	WB	5	26.6	1.4	1.4	ND	ND	ND	1.4	ND	ND	ND
6/2/00	San Pablo Bay	Jacksnail	WB	5	27.2	0.8	1.1	ND	ND	ND	1.1	ND	ND	ND
6/2/00	San Pablo Bay	Jacksnail	WB	5	27.6	0.6	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Jacksnail	WB	5	27.0	0.7	1.2	ND	ND	ND	1.2	ND	ND	ND
5/1/00	South Bay Bridges	Jacksnail	WB	5	28.4	1.2	5.8	2.4	ND	ND	3.4	ND	ND	ND
5/1/00	South Bay Bridges	Jacksnail	WB	5	27.8	1.2	2.9	ND	ND	ND	2.9	ND	ND	ND
5/1/00	South Bay Bridges	Jacksnail	WB	5	27.4	1.4	3.3	ND	ND	ND	3.3	ND	ND	ND
5/24/00	Berkeley	Leopard Shark	Off	3	92.3	0.4	ND	ND	ND	ND	ND	ND	ND	ND
5/25/00	Berkeley	Leopard Shark	Off	3	107.3	0.4	ND	ND	ND	ND	ND	ND	ND	ND
6/6/00	San Pablo Bay	Leopard Shark	Off	3	104.0	0.4	ND	ND	ND	ND	ND	ND	ND	ND
6/7/00	San Pablo Bay	Leopard Shark	Off	3	91.3	0.7	ND	ND	ND	ND	ND	ND	ND	ND
5/16/00	South Bay Bridges	Leopard Shark	Off	3	126.3	0.4	1.2	ND	ND	ND	1.2	ND	ND	ND
5/16/00	South Bay Bridges	Leopard Shark	Off	3	95.7	0.4	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	Striped Bass	Off	3	51.0	0.8	1.2	ND	ND	ND	1.2	ND	ND	ND
5/25/00	Berkeley	Striped Bass	Off	3	51.7	0.7	1.6	ND	ND	ND	1.6	ND	ND	ND
5/26/00	Berkeley	Striped Bass	Off	3	67.0	1.4	5.7	2.2	ND	ND	3.5	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	51.3	1.3	1.2	ND	ND	ND	1.2	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	53.0	1.1	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	52.7	1.5	1.0	ND	ND	ND	1.0	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	65.7	1.1	1.1	ND	ND	ND	1.1	ND	ND	ND
5/16/00	South Bay Bridges	Striped Bass	Off	3	48.7	1.2	1.5	ND	ND	ND	1.5	ND	ND	ND
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.0	1.2	ND	ND	ND	ND	ND	ND	ND	ND
5/18/00	South Bay Bridges	Striped Bass	Off	3	50.0	1.0	1.4	ND	ND	ND	1.4	ND	ND	ND
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.2	4.1	2.0	ND	ND	ND	2.0	ND	ND	ND
5/5/00	Berkeley	Shiner Surfperch	WB	20	12.5	3.6	2.4	ND	ND	ND	2.4	ND	ND	ND
5/5/00	Berkeley	Shiner Surfperch	WB	20	13.1	3.6	4.7	2.4	ND	ND	2.4	ND	ND	ND
6/16/00	Oakland	Shiner Surfperch	WB	20	12.1	1.3	18.5	5.9	2.3	3.5	6.8	ND	ND	ND
6/21/00	Oakland	Shiner Surfperch	WB	20	11.6	1.1	12.8	4.8	ND	2.7	5.3	ND	ND	ND
6/22/00	Oakland	Shiner Surfperch	WB	19	11.4	0.8	10.1	3.5	ND	2.2	4.4	ND	ND	ND
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.3	2.6	1.9	ND	ND	ND	1.9	ND	ND	ND
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.5	3.8	2.1	ND	ND	ND	2.1	ND	ND	ND
5/3/00	S F Waterfront	Shiner Surfperch	WB	20	11.4	2.8	2.1	ND	ND	ND	2.1	ND	ND	ND
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	10.4	2.5	25.5	7.7	3.0	4.6	8.8	ND	ND	e 1.4
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	9.9	2.2	21.9	6.3	2.5	4.1	7.9	ND	ND	e 1.1
11/14/00	San Leandro Bay	Shiner Surfperch	WB	20	8.4	2.1	26.0	8.3	3.5	4.7	8.2	ND	ND	e 1.4
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.2	3.0	4.2	2.0	ND	ND	2.2	ND	ND	ND
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9.5	3.1	1.6	ND	ND	ND	1.6	ND	ND	ND
11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	10.1	3.6	6.2	3.2	ND	ND	3.0	ND	ND	ND
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	12.8	2.4	18.0	5.5	2.3	3.7	6.5	ND	ND	ND
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	12.5	2.6	10.1	3.5	ND	2.5	4.1	ND	ND	ND
5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11.0	2.0	10.0	3.5	ND	2.4	4.1	ND	ND	ND
3/21/00	San Pablo Bay	White Sturgeon	Off	3	119.0	0.6	ND	ND	ND	ND	ND	ND	ND	ND
3/22/00	San Pablo Bay	White Sturgeon	Off	3	143.0	1.8	1.8	ND	ND	ND	1.8	ND	ND	ND
4/19/00	South Bay Bridges	White Sturgeon	Off	3	124.3	0.5	1.1	ND	ND	ND	1.1	ND	ND	ND
4/19/00	South Bay Bridges	White Sturgeon	Off	3	155.3	0.8	1.5	ND	ND	ND	1.5	ND	ND	ND
5/24/00	Berkeley	White Croaker	On	5	27.6	2.3	8.2	2.4	ND	2.3	3.5	ND	ND	ND
5/24/00	Berkeley	White Croaker	On	5	26.4	2.7	2.2	ND	ND	ND	2.2	ND	ND	ND
5/24/00	Berkeley	White Croaker	On	5	27.4	3.0	4.7	2.0	ND	ND	2.6	ND	ND	ND
3/8/00	Oakland	White Croaker	On	5	25.2	1.9	5.7	2.5	ND	ND	3.2	ND	ND	ND
3/8/00	Oakland	White Croaker	On	5	23.6	1.0	1.5	ND	ND	ND	1.5	ND	ND	ND
3/8/00	Oakland	White Croaker	On	5	24.8	1.8	5.3	2.3	ND	ND	2.9	ND	ND	ND
6/16/00	Oakland	White Croaker	On	5	24.0	4.8	15.3	4.5	2.3	3.2	5.3	ND	ND	ND
6/20/00	Oakland	White Croaker	On	5	24.8	6.3	9.1	3.2	ND	2.2	3.7	ND	ND	ND
6/20/00	Oakland	White Croaker	On	5	27.4	5.7	18.6	5.2	2.7	3.9	6.8	ND	ND	ND
9/26/00	Oakland	White Croaker	On	5	25.4	6.0	22.2	6.9	3.4	4.4	7.5	ND	ND	ND
9/26/00	Oakland	White Croaker	On	5	25.6	7.3	12.1	3.9	ND	3.3	4.9	ND	ND	ND
9/26/00	Oakland	White Croaker	On	5	26.0	5.5	12.0	3.9	ND	3.2	4.9	ND	ND	ND
12/18/00	Oakland	White Croaker	On	5	23.8	6.3	17.1	5.5	3.1	3.3	5.3	ND	ND	ND
12/18/00	Oakland	White Croaker	On	5	25.5	4.1	5.7	2.6	ND	ND	3.1	ND	ND	ND
12/18/00	Oakland	White Croaker	On	5	23.4	4.9	5.4	2.6	ND	ND	2.8	ND	ND	ND
5/3/00	S F Waterfront	White Croaker	On	5	27.6	2.0	5.4	2.2	ND	ND	3.2	ND	ND	ND
5/3/00	S F Waterfront	White Croaker	On	5	26.6	1.8	7.9	2.2	ND	2.1	3.6	ND	ND	ND
5/3/00	S F Waterfront	White Croaker	On	5	24.8	2.2	4.5	2.0	ND	ND	2.4	ND	ND	ND
6/2/00	San Pablo Bay	White Croaker	On	5	28.0	4.4	9.4	2.7	ND	2.7	4.0	ND	ND	ND
6/8/00	San Pablo Bay	White Croaker	On	5	28.0	4.9	14.3	3.7	ND	4.2	6.3	ND	ND	ND
6/8/00	San Pablo Bay	White Croaker	On	5	28.6	5.3	13.6	3.9	ND	3.9	5.8	ND	ND	ND
5/1/00	South Bay Bridges	White Croaker	On	5	27.8	2.8	11.9	3.4	ND	3.5	5.1	ND	ND	ND
5/1/00	South Bay Bridges	White Croaker	On	5	26.4	4.4	14.7	4.3	2.0	3.1	5.3	ND	ND	ND
5/1/00	South Bay Bridges	White Croaker	On	5	27.8	4.0	12.5	3.9	ND	3.3	5.3	ND	ND	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	12.3	0.1	ND	ND	ND	ND	ND	ND	ND	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	12.2	0.2	ND	ND	ND	ND	ND	ND	ND	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	H	20	12.3	3.1	2.8	ND	ND	ND	1.7	ND	ND	1.2
9/29/99	Fort Baker	Red Rock Crab	M	10	11.1	0.2	ND	ND	ND	ND	ND	ND	ND	ND
9/29/99	Fort Baker	Red Rock Crab	M	10	11.3	0.2	ND	ND	ND	ND	ND	ND	ND	ND
9/29/99	Fort Baker	Red Rock Crab	H	20	11.2	4.3	3.8	ND	ND	ND	2.1	ND	ND	1.7
9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	M	10	12.1	0.2	ND	ND	ND	ND	ND	ND	ND	ND
9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	M	10	11.2	0.4	ND	ND	ND	ND	ND	ND	ND	ND
9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	H	20	11.7	8.5	5.0	ND	ND	ND	3.0	ND	ND	2.0
4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	NA	0.8	ND	ND	ND	ND	ND	ND	ND	ND
4/8/98	Frutvela Bridge (Oakland)	Tapes Japonica Clam	All	25	NA	0.9	ND	ND	ND	ND	ND	ND	ND	ND

Units expressed as wet weight. e = Estimated value, ND = Not detected.
 Off = Skin-off muscle, On = Skin-on muscle, WB = Whole body, H = Crab hepatopancreas, All = Clam soft tissue
 Total Chlordanes (SFEI) = Sum of 5 chlordanes, following SFEI RMP protocol

Appendix Table 2c. Pesticide concentrations in fish, crab, and clam tissue samples, 1998-2000 (continued).

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Average Length	% Lipids	Sum HCHs (SFEI)	alpha-HCH	beta-HCH	delta-HCH	gamma-HCH	Mirex	Hexachlorobenzene	Aldrin	Dieldrin	Endrin
					cm	%	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
5/3/00	S F Waterfront	California Halibut	Off	3	67.0	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/4/00	S F Waterfront	California Halibut	Off	3	91.3	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	California Halibut	Off	3	63.7	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	Jacksmelt	WB	5	26.0	2.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/14/00	Berkeley	Jacksmelt	WB	5	26.8	2.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/15/00	Berkeley	Jacksmelt	WB	5	27.4	3.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/21/00	Oakland	Jacksmelt	WB	5	26.8	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/21/00	Oakland	Jacksmelt	WB	5	27.4	2.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/22/00	Oakland	Jacksmelt	WB	5	27.0	2.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3/00	S F Waterfront	Jacksmelt	WB	5	25.8	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/4/00	S F Waterfront	Jacksmelt	WB	5	28.4	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/4/00	S F Waterfront	Jacksmelt	WB	5	26.6	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.2	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Jacksmelt	WB	5	27.6	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/1/00	South Bay Bridges	Jacksmelt	WB	5	27.0	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/1/00	South Bay Bridges	Jacksmelt	WB	5	27.8	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/1/00	South Bay Bridges	Jacksmelt	WB	5	27.4	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	Leopard Shark	Off	3	92.3	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/25/00	Berkeley	Leopard Shark	Off	3	107.3	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6/00	San Pablo Bay	Leopard Shark	Off	3	104.0	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/7/00	San Pablo Bay	Leopard Shark	Off	3	91.3	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/16/00	South Bay Bridges	Leopard Shark	Off	3	126.3	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/16/00	South Bay Bridges	Leopard Shark	Off	3	96.7	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	Striped Bass	Off	3	51.0	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/25/00	Berkeley	Striped Bass	Off	3	51.7	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/26/00	Berkeley	Striped Bass	Off	3	67.0	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	51.3	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	53.0	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	52.7	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	Striped Bass	Off	3	65.7	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.7	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/18/00	South Bay Bridges	Striped Bass	Off	3	48.0	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/18/00	South Bay Bridges	Striped Bass	Off	3	50.0	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/5/00	Berkeley	Shiner Surperch	WB	20	12.2	4.1	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND
5/5/00	Berkeley	Shiner Surperch	WB	20	12.5	3.8	ND	ND	ND	ND	ND	ND	0.5	ND	ND	ND
5/5/00	Berkeley	Shiner Surperch	WB	20	13.1	3.6	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND
6/18/00	Oakland	Shiner Surperch	WB	20	12.1	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/21/00	Oakland	Shiner Surperch	WB	20	11.6	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/22/00	Oakland	Shiner Surperch	WB	19	11.4	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3/00	S F Waterfront	Shiner Surperch	WB	20	11.3	2.6	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND
5/3/00	S F Waterfront	Shiner Surperch	WB	20	11.5	3.8	ND	ND	ND	ND	ND	ND	0.5	ND	ND	ND
5/3/00	S F Waterfront	Shiner Surperch	WB	20	11.4	2.8	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND
11/14/00	San Leandro Bay	Shiner Surperch	WB	20	10.4	2.5	ND	ND	ND	ND	ND	ND	ND	ND	2.7	ND
11/14/00	San Leandro Bay	Shiner Surperch	WB	20	9.9	2.2	ND	ND	ND	ND	ND	ND	ND	ND	2.3	ND
11/14/00	San Leandro Bay	Shiner Surperch	WB	20	8.4	2.1	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND
11/29/00	San Pablo Bay	Shiner Surperch	WB	20	10.2	3.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/29/00	San Pablo Bay	Shiner Surperch	WB	20	9.5	3.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/29/00	San Pablo Bay	Shiner Surperch	WB	20	10.1	3.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/1/00	South Bay Bridges	Shiner Surperch	WB	20	12.6	2.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/1/00	South Bay Bridges	Shiner Surperch	WB	20	12.5	2.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/1/00	South Bay Bridges	Shiner Surperch	WB	20	11.0	2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/21/00	San Pablo Bay	White Sturgeon	Off	3	119.0	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/22/00	San Pablo Bay	White Sturgeon	Off	3	143.0	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/19/00	South Bay Bridges	White Sturgeon	Off	3	124.3	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/19/00	South Bay Bridges	White Sturgeon	Off	3	155.3	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	White Croaker	On	5	27.6	2.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	White Croaker	On	5	26.4	2.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/24/00	Berkeley	White Croaker	On	5	27.4	3.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/8/00	Oakland	White Croaker	On	5	25.2	1.8	ND	ND	ND	ND	ND	ND	ND	ND	4.4	ND
3/8/00	Oakland	White Croaker	On	5	23.6	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/16/00	Oakland	White Croaker	On	5	24.8	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/20/00	Oakland	White Croaker	On	5	24.0	4.8	ND	ND	ND	ND	ND	ND	0.3	ND	2.3	ND
6/20/00	Oakland	White Croaker	On	5	24.8	8.3	ND	ND	ND	ND	ND	ND	ND	ND	2.3	ND
6/20/00	Oakland	White Croaker	On	5	27.4	5.7	ND	ND	ND	ND	ND	ND	0.3	ND	2.7	ND
9/26/00	Oakland	White Croaker	On	5	25.4	8.0	ND	ND	ND	ND	ND	ND	0.4	ND	3.7	ND
9/26/00	Oakland	White Croaker	On	5	25.8	7.3	ND	ND	ND	ND	ND	ND	0.3	ND	2.7	ND
9/26/00	Oakland	White Croaker	On	5	26.0	5.5	ND	ND	ND	ND	ND	ND	ND	ND	2.3	ND
12/18/00	Oakland	White Croaker	On	5	23.8	8.3	ND	ND	ND	ND	ND	ND	0.4	ND	3.4	ND
12/18/00	Oakland	White Croaker	On	4	25.5	4.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/18/00	Oakland	White Croaker	On	5	23.4	4.9	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND
5/3/00	S F Waterfront	White Croaker	On	5	27.8	2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3/00	S F Waterfront	White Croaker	On	5	26.6	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3/00	S F Waterfront	White Croaker	On	5	24.6	2.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/00	San Pablo Bay	White Croaker	On	5	28.0	4.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/8/00	San Pablo Bay	White Croaker	On	5	28.0	4.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/8/00	San Pablo Bay	White Croaker	On	5	28.8	5.3	ND	ND	ND	ND	ND	ND	ND	ND	2.0	ND
5/1/00	South Bay Bridges	White Croaker	On	5	27.8	2.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/1/00	South Bay Bridges	White Croaker	On	5	26.4	4.4	ND	ND	ND	ND	ND	ND	ND	ND	2.3	ND
5/1/00	South Bay Bridges	White Croaker	On	5	27.8	4.0	ND	ND	ND	ND	ND	ND	ND	ND	2.3	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	12.3	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	M	10	12.2	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/28/99	SF Waterfront (Muni Pier)	Red Rock Crab	H	20	12.3	3.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/29/99	Fort Baker	Red Rock Crab	M	10	11.1	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/29/99	Fort Baker	Red Rock Crab	M	10	11.3	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/29/99	Fort Baker	Red Rock Crab	H	20	11.2	4.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	M	10	12.1	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	M	10	11.2	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/30/99	SF Waterfront (7th St Pier)	Red Rock Crab	H	20	11.7	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	NA	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	All	25	NA	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Units expressed as wet weight ND = Not detected

Off = Skin-off muscle On = Skin-on muscle WB = Whole body M = Crab muscle H = Crab hepatopancreas All = Clam soft tissue

Sum HCHs (SFEI) = Sum of 4 listed HCHs following SFEI RMP protocol

Appendix Table 2d. Polybrominated diphenyl ether (PBDE) concentrations in fish tissue samples, 1998-2000. All values are semi-quantitative estimates (see report text).

Sample ID	Fish ID	Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths	Average Length	% Lipids	PBDE 47	PBDE 99	PBDE 153	Total PBDEs
							cm	cm	%	ng/g	ng/g	ng/g	ng/g
C003601	134	5/3/2000	S F Waterfront	California Halibut	Off	3	55, 64, 82	67.0	0.4	3.5e	0.1e	0.0e	3.7e
C003602	135	5/4/2000	S F Waterfront	California Halibut	Off	3	84, 92, 98	91.3	0.3	2.4e	0.1e	0.0e	2.4e
C005601	167	6/2/2000	San Pablo Bay	California Halibut	Off	3	55, 61, 75	63.7	0.4	2.7e	0.3e	0.0e	3.0e
C004301	142	5/24/2000	Berkeley	Jacksnelt	WB	5	24 - 28	26.0	2.6	1.6e	0.9e	0.2e	2.6e
C004302	143	6/14/2000	Berkeley	Jacksnelt	WB	5	25 - 28	26.6	2.5	1.9e	1.2e	0.2e	3.3e
C004303	144	6/15/2000	Berkeley	Jacksnelt	WB	5	26 - 29	27.4	3.0	1.5e	0.7e	0.0e	2.2e
C002301	121	6/21/2000	Oakland	Jacksnelt	WB	5	25 - 30	26.8	1.5	4.5e	2.6e	0.0e	7.1e
C002302	122	6/21/2000	Oakland	Jacksnelt	WB	5	28 - 29	27.4	2.3	2.4e	1.4e	0.2e	4.0e
C002303	123	6/22/2000	Oakland	Jacksnelt	WB	5	25 - 29	27.0	2.1	1.9e	1.3e	0.2e	3.3e
C003301	131	5/3/2000	S F Waterfront	Jacksnelt	WB	5	24 - 27	25.8	1.0	2.4e	1.2e	0.2e	3.9e
C003302	132	5/4/2000	S F Waterfront	Jacksnelt	WB	5	25 - 28	26.4	1.0	2.7e	1.5e	0.3e	4.5e
C003303	133	5/4/2000	S F Waterfront	Jacksnelt	WB	5	25 - 28	26.6	1.4	3.0e	1.4e	0.3e	4.7e
C005301	157	6/2/2000	San Pablo Bay	Jacksnelt	WB	5	26 - 28	27.2	0.8	2.5e	1.4e	0.4e	4.3e
C005302	158	6/2/2000	San Pablo Bay	Jacksnelt	WB	5	27 - 28	27.6	0.6	2.2e	1.2e	0.3e	3.6e
C005303	159	6/2/2000	San Pablo Bay	Jacksnelt	WB	5	25 - 29	27.0	0.7	3.1e	1.6e	0.4e	5.0e
C001301	94	5/1/2000	South Bay Bndges	Jacksnelt	WB	5	27 - 29	28.4	1.2	3.1e	2.0e	0.3e	5.3e
C001302	95	5/1/2000	South Bay Bndges	Jacksnelt	WB	5	27 - 28	27.8	1.2	5.3e	2.8e	0.6e	8.7e
C001303	96	5/1/2000	South Bay Bndges	Jacksnelt	WB	5	26 - 29	27.4	1.4	3.8e	2.3e	0.4e	6.5e
C004402	146	5/24/2000	Berkeley	Leopard Shark	Off	3	92, 92, 93	92.3	0.4	0.7e	0.0e	0.0e	0.7e
C004403	147	5/25/2000	Berkeley	Leopard Shark	Off	3	99, 110, 113	107.3	0.4	2.7e	0.0e	0.0e	2.7e
C005403	162	6/6/2000	San Pablo Bay	Leopard Shark	Off	3	98, 107, 107	104.0	0.4	0.8e	0.1e	0.0e	0.8e
C005402	161	6/7/2000	San Pablo Bay	Leopard Shark	Off	3	90, 91, 93	91.3	0.7	1.2e	0.1e	0.0e	1.3e
C001404	100	5/16/2000	South Bay Bndges	Leopard Shark	Off	3	120, 125, 134	126.3	0.4	6.9e	0.2e	0.1e	7.2e
C001401	97	5/16/2000	South Bay Bndges	Leopard Shark	Off	3	92, 98, 100	96.7	0.4	2.0e	0.0e	0.0e	2.0e
C004501	148	5/24/2000	Berkeley	Strped Bass	Off	3	48, 51, 54	51.0	0.8	15.6e	0.2e	0.2e	16.0e
C004502	149	5/25/2000	Berkeley	Strped Bass	Off	3	51, 51, 53	51.7	0.7	7.6e	0.3e	0.1e	8.1e
C004503	150	5/26/2000	Berkeley	Strped Bass	Off	3	61, 62, 78	67.0	1.4	11.5e	0.4e	0.3e	12.2e
C005501	163	6/2/2000	San Pablo Bay	Strped Bass	Off	3	45, 51, 58	51.3	1.3	8.2e	0.4e	0.3e	8.8e
C005502	164	6/2/2000	San Pablo Bay	Strped Bass	Off	3	50, 54, 55	53.0	1.1	4.9e	0.1e	0.0e	5.0e
C005503	165	6/2/2000	San Pablo Bay	Strped Bass	Off	3	50, 51, 57	52.7	1.5	6.0e	0.3e	0.0e	6.4e
C005504	166	6/2/2000	San Pablo Bay	Strped Bass	Off	3	60, 62, 75	65.7	1.1	5.1e	0.2e	0.0e	5.3e
C001501	101	5/18/2000	South Bay Bndges	Strped Bass	Off	3	47, 49, 50	48.7	1.2	6.4e	0.2e	0.0e	6.6e
C001502	102	5/18/2000	South Bay Bndges	Strped Bass	Off	3	45, 47, 52	48.0	1.2	6.0e	0.3e	0.0e	6.3e
C001503	103	5/18/2000	South Bay Bndges	Strped Bass	Off	3	46, 47, 57	50.0	1.0	4.6e	0.3e	0.0e	5.1e
C004201	139	5/5/2000	Berkeley	Shiner Surfperch	WB	20	11 - 13	12.2	4.1	12.2e	0.7e	0.0e	12.9e
C004202	140	5/5/2000	Berkeley	Shiner Surfperch	WB	20	11 - 14	12.5	3.6	16.0e	0.5e	0.0e	16.5e
C004203	141	5/5/2000	Berkeley	Shiner Surfperch	WB	20	11 - 15	13.1	3.6	15.9e	0.7e	0.0e	16.6e
C002202	119	6/16/2000	Oakland	Shiner Surfperch	WB	20	11 - 15	12.1	1.3	19.7e	0.5e	0.0e	20.2e
C002201	118	6/21/2000	Oakland	Shiner Surfperch	WB	20	10 - 13	11.6	1.1	15.3e	0.4e	0.0e	15.7e
C002203	120	6/22/2000	Oakland	Shiner Surfperch	WB	19	10 - 14	11.4	0.8	12.1e	0.3e	0.0e	12.4e
C003201	126	5/3/2000	S F Waterfront	Shiner Surfperch	WB	20	10 - 14	11.3	2.6	12.0e	0.3e	0.0e	12.3e
C003202	129	5/3/2000	S F Waterfront	Shiner Surfperch	WB	20	10 - 13	11.5	3.8	20.5e	0.6e	0.0e	21.1e
C003203	130	5/3/2000	S F Waterfront	Shiner Surfperch	WB	20	10 - 13	11.4	2.8	18.0e	0.5e	0.0e	18.5e
C008201	170	11/14/2000	San Leandro Bay	Shiner Surfperch	WB	20	9 - 12	10.4	2.5	14.3e	0.6e	0.0e	14.9e
C008202	171	11/14/2000	San Leandro Bay	Shiner Surfperch	WB	20	9 - 11	9.9	2.2	11.6e	0.5e	0.0e	12.3e
C008203	172	11/14/2000	San Leandro Bay	Shiner Surfperch	WB	20	8 - 10	8.4	2.1	11.7e	0.5e	0.0e	12.2e
C005203	156	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 12	10.1	3.6	6.3e	0.3e	0.0e	6.6e
C005201	154	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 12	10.2	3.0	5.4e	0.3e	0.0e	5.7e
C005202	155	11/29/00	San Pablo Bay	Shiner Surfperch	WB	20	9 - 11	9.5	3.1	5.1e	0.3e	0.0e	5.4e
C001201	91	5/1/2000	South Bay Bndges	Shiner Surfperch	WB	20	11 - 15	12.6	2.4	24.5e	1.2e	0.2e	25.8e
C001202	92	5/1/2000	South Bay Bndges	Shiner Surfperch	WB	20	11 - 14	12.5	2.6	21.0e	1.2e	0.2e	22.4e
C001203	93	5/1/2000	South Bay Bndges	Shiner Surfperch	WB	20	10 - 14	11.0	2.0	18.3e	1.0e	0.2e	19.4e
C005701	168	3/21/2000	San Pablo Bay	White Sturgeon	Off	3	115, 117, 125	119.0	0.6	2.4e	0.3e	0.0e	2.7e
C005702	169	3/22/2000	San Pablo Bay	White Sturgeon	Off	3	133, 147, 149	143.0	1.8	6.5e	0.7e	0.2e	7.4e
C001701	104	4/19/2000	South Bay Bndges	White Sturgeon	Off	3	121, 122, 123	124.3	0.5	2.3e	0.2e	0.0e	2.5e
C001702	105	4/19/2000	South Bay Bndges	White Sturgeon	Off	3	135, 149, 182	155.3	0.8	3.8e	0.1e	0.0e	3.7e
C004101	136	5/24/2000	Berkeley	White Croaker	On	5	24 - 29	27.6	2.3	21.9e	0.3e	0.2e	22.4e
C004102	137	5/24/2000	Berkeley	White Croaker	On	5	24 - 28	26.4	2.7	14.6e	0.4e	0.4e	15.4e
C004103	138	5/24/2000	Berkeley	White Croaker	On	5	25 - 29	27.4	3.0	18.2e	0.4e	0.4e	19.0e
C002110	115	12/18/2000	Oakland	White Croaker	On	5	21 - 30	23.8	6.3	28.3e	1.4e	0.8e	30.5e
C002111	116	12/18/2000	Oakland	White Croaker	On	5	22 - 29	25.5	4.1	27.5e	0.9e	0.5e	28.9e
C002112	117	12/18/2000	Oakland	White Croaker	On	5	21 - 27	23.4	4.9	25.4e	1.4e	0.7e	27.5e
C002104	109	3/8/2000	Oakland	White Croaker	On	5	23 - 27	25.2	1.9	18.1e	0.9e	0.7e	19.7e
C002105	110	3/8/2000	Oakland	White Croaker	On	5	22 - 25	23.6	1.0	13.7e	1.4e	0.9e	15.9e
C002106	111	3/8/2000	Oakland	White Croaker	On	5	21 - 28	24.8	1.8	23.1e	1.8e	1.3e	26.2e
C002101	106	6/16/2000	Oakland	White Croaker	On	5	21 - 28	24.0	4.8	27.1e	0.7e	0.6e	28.4e
C002102	107	6/20/2000	Oakland	White Croaker	On	5	22 - 28	24.8	6.3	36.9e	1.9e	1.0e	39.8e
C002103	108	6/20/2000	Oakland	White Croaker	On	5	24 - 29	27.4	5.7	40.8e	1.5e	1.0e	43.3e
C002107	112	9/26/2000	Oakland	White Croaker	On	5	22 - 29	25.4	6.0	31.9e	0.7e	0.7e	33.3e
C002108	113	9/26/2000	Oakland	White Croaker	On	4	22 - 30	25.6	7.3	56.5e	1.5e	1.1e	59.1e
C002109	114	9/26/2000	Oakland	White Croaker	On	5	21 - 30	26.0	5.5	47.6e	1.4e	1.0e	50.0e
C003101	125	5/3/2000	S F Waterfront	White Croaker	On	5	25 - 30	27.6	2.0	25.9e	0.6e	0.6e	27.1e
C003102	126	5/3/2000	S F Waterfront	White Croaker	On	5	25 - 28	26.6	1.8	26.6e	0.4e	0.3e	27.2e
C003103	127	5/3/2000	S F Waterfront	White Croaker	On	5	22 - 27	24.8	2.2	17.3e	0.4e	0.3e	18.0e
C005103	153	6/2/2000	San Pablo Bay	White Croaker	On	5	25 - 30	28.0	4.4	25.5e	1.0e	0.5e	27.0e
C005101	151	6/8/2000	San Pablo Bay	White Croaker	On	5	23 - 30	28.0	4.9	28.0e	0.8e	0.4e	29.2e
C005102	152	6/8/2000	San Pablo Bay	White Croaker	On	5	27 - 30	28.6	5.3	36.0e	0.9e	0.5e	37.4e
C001101	88	5/1/2000	South Bay Bndges	White Croaker	On	5	26 - 30	27.8	2.8	25.3e	0.9e	0.4e	26.6e
C001102	89	5/1/2000	South Bay Bndges	White Croaker	On	5	24 - 30	26.4	4.4	23.1e	1.6e	0.7e	25.4e
C001103	90	5/1/2000	South Bay Bndges	White Croaker	On	5	26 - 30	27.8	4.0	27.2e	1.3e	0.8e	29.3e

Units expressed as wet weight ND = not detected Off = Skin-off muscle, On = Skin-on muscle, WB = Whole body
e = estimated value (semi-quantitative only) because standards were analysed on separate day from samples and because there weren't any QC results to verify sample results
Sample ID and Fish ID are unique identifiers for each individual or composite fish sample

Appendix Table 2e. Dibenzodioxin, dibenzofuran, and coplanar PCB concentrations (pg/g) in fish and crab tissue samples, 1999 - 2000.

Sample ID	Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths	% Lipids	TEQ-WHO (0)	TEQ-WHO (0.5)	TEQ-WHO (1)	ITEQ (0.5)	PCB TEQ (3 PCBs) (0.5)	PCB TEQ (0.5)	Total TEQ	2,3,7,8-TCDD	1,2,3,7,8-PCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8-HxCDD	1,2,3,4,6,7,8-HxCDD	1,2,3,4,6,7,8-OCDD	2,3,7,8-TCDF	1,2,3,7,8-PCDF	2,3,4,7,8-PCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	1,2,3,7,8-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,4,6,7,8-OCDF	PCB 77	PCB 126	PCB 169						
C002304	8/12/00	Oakland	Jacksmelt	WB	15	25-30	1.75	0.13	0.20	0.27	0.19	1.47	2.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C001201	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11-15	2.38	1.58	1.59	1.61	1.38	4.48	6.55	0.15	0.20	0.42	ND	0.19	ND	0.21	0.48	0.78	0.48	0.87	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C001202	5/1/00	South Bay Bridges	Shiner Surfperch	WB	20	11-14	2.82	1.39	1.41	1.43	1.28	3.40	5.06	0.47	0.20	0.30	ND	0.23	0.40	0.81	0.25	0.78	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C002201	6/1/00	Oakland	Shiner Surfperch	WB	20	10-13	1.07	2.52	2.52	2.53	2.08	7.81	11.12	13.85	0.40	0.94	0.18	0.64	0.17	0.88	1.27	4.48	0.47	1.12	0.14	0.12	ND	0.17	0.22	ND	ND	ND	ND	ND				
C002202	6/1/00	Oakland	Shiner Surfperch	WB	20	11-15	1.31	2.56	2.56	2.57	2.15	9.83	13.98	16.52	0.37	0.83	0.14	0.85	0.17	0.85	1.10	5.56	0.34	1.27	0.14	0.12	ND	0.17	0.19	ND	ND	ND	ND	ND				
C003201	5/3/00	San Francisco Waterfront	Shiner Surfperch	WB	20	10-14	2.63	1.05	1.08	1.08	0.95	2.68	4.02	5.08	0.15	0.22	ND	ND	ND	0.16	0.53	0.98	0.25	0.53	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C003202	5/3/00	San Francisco Waterfront	Shiner Surfperch	WB	20	10-13	3.78	1.21	1.22	1.23	1.15	3.54	5.17	6.39	0.12	0.13	ND	0.15	ND	0.26	1.83	5.46	0.45	0.72	0.09	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C004202	5/5/00	Berkeley	Shiner Surfperch	WB	20	11-14	3.61	1.47	1.48	1.48	1.30	3.20	4.54	6.01	0.13	0.35	0.05	0.17	ND	0.13	0.80	0.52	0.29	0.82	0.07	0.8	ND	ND	ND	ND	ND	ND	ND	ND				
C004203	5/5/00	Berkeley	Shiner Surfperch	WB	20	11-15	3.58	0.87	0.94	1.01	0.82	3.29	4.64	5.58	0.10	ND	ND	ND	ND	ND	0.48	0.8	4.19	0.21	0.88	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND			
C001501	5/18/00	South Bay Bridges	Striped Bass	Off	3	47-49	5.0	1.19	0.00	0.05	0.11	0.05	0.01	0.70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C001502	5/18/00	South Bay Bridges	Striped Bass	Off	3	45-47	5.2	1.23	0.18	0.22	0.29	0.21	0.87	1.10	1.32	ND	ND	ND	ND	0.34	0.53	0.05	0.20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C001503	5/18/00	South Bay Bridges	Striped Bass	Off	3	48-47	5.7	1.04	0.03	0.14	0.26	0.13	0.54	0.62	1.06	ND	ND	ND	ND	1.34	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
C004501	5/24/00	Berkeley	Striped Bass	Off	3	48-51	5.4	0.757	0.11	0.11	0.12	0.11	0.45	0.99	1.10	0.02	0.8	ND	NA	NA	NA	NA	0.13	0.27	ND	0.12	NA	NA	NA	NA	NA	NA	0.06	0.8	13	4	0	
C004502	5/25/00	Berkeley	Striped Bass	Off	3	51-51	5.3	0.71	0.26	0.26	0.26	0.22	0.83	1.50	1.76	0.03	0.8	ND	NA	NA	NA	ND	0.27	0.37	ND	0.22	NA	NA	NA	NA	NA	NA	0.11	0.8	19	8	1	
C004503	5/28/00	Berkeley	Striped Bass	Off	3	61-62	7.8	1.35	0.27	0.28	0.29	0.23	1.39	2.15	2.43	ND	0.10	ND	ND	0.11	0.8	0.24	0.90	0.03	0.21	ND	ND	0.05	0.8	0.06	0.8	0.05	0.8	0.12	0.8	42	14	1
C055501	6/2/00	San Pablo Bay	Striped Bass	Off	3	45-51	5.8	1.27	0.22	0.22	0.23	0.19	0.84	1.08	1.30	ND	0.08	0.8	0.07	0.8	0.08	0.25	0.36	0.03	0.16	NA	0.04	0.8	0.07	0.8	0.04	0.8	0.06	0.8	0.15	17	8	1
C055502	6/2/00	San Pablo Bay	Striped Bass	Off	3	50-54	5.5	1.07	0.24	0.24	0.25	0.21	0.64	0.88	1.23	ND	0.07	0.8	0.05	0.8	0.12	0.39	0.34	0.02	0.18	0.03	0.8	0.04	0.8	0.06	0.8	0.07	0.8	0.08	0.8	0.18	8	0
C055503	6/2/00	San Pablo Bay	Striped Bass	Off	3	50-51	5.7	1.46	0.11	0.12	0.14	0.12	0.83	1.09	1.21	ND	ND	ND	ND	0.07	0.8	0.19	0.29	0.01	0.15	ND	ND	ND	ND	ND	ND	ND	ND	0.06	0.8	18	6	0
C055504	6/2/00	San Pablo Bay	Striped Bass	Off	3	60-82	7.5	1.09	NA	NA	NA	NA	0.94	0.99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	18	6	NA	
C001101	5/1/00	South Bay Bridges	White Croaker	On	5	26-30	2.84	1.85	1.68	1.68	1.33	4.25	6.46	8.11	ND	0.65	NA	NA	NA	0.16	0.8	0.09	2.13	ND	1.57	NA	NA	NA	NA	NA	NA	NA	ND	ND	63	42	3	
C001102	5/1/00	South Bay Bridges	White Croaker	On	5	24-30	4.38	1.86	1.66	1.67	1.38	3.04	4.87	6.53	0.03	0.8	0.06	0.8	0.28	0.4	0.11	0.8	2.61	0.39	1.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	79	30	2	
C001103	5/1/00	South Bay Bridges	White Croaker	On	5	28-30	3.98	1.55	1.55	1.56	1.34	3.14	5.13	6.69	0.15	0.43	0.07	0.8	0.35	ND	0.16	0.8	2.77	2.82	0.33	1.24	ND	ND	ND	ND	0.45	ND	0.05	74	31	3		
C002101	6/1/00	Oakland	White Croaker	On	5	21-28	4.64	1.97	1.97	1.98	1.89	8.48	9.71	11.68	0.35	0.57	ND	0.28	0.4	0.10	0.8	2.28	2.36	0.27	1.53	ND	ND	ND	ND	ND	ND	ND	ND	ND	126	84	3	
C002102	6/2/00	Oakland	White Croaker	On	5	22-28	6.26	1.98	1.98	1.99	1.68	4.11	6.83	8.61	0.14	0.81	0.06	0.8	0.38	ND	0.13	0.8	2.18	3.96	0.28	1.53	ND	ND	ND	0.49	ND	ND	ND	ND	132	46	3	
C002103	6/2/00	Oakland	White Croaker	On	5	24-29	5.69	2.36	2.36	2.38	2.05	8.16	10.63	12.44	0.39	0.85	0.04	0.8	0.39	0.07	0.18	0.25	3.55	ND	1.84	ND	ND	ND	ND	1.06	ND	ND	ND	ND	154	61	4	
C003101	5/3/00	San Francisco Waterfront	White Croaker	On	5	25-30	2.03	0.75	0.78	0.80	0.87	2.47	4.15	4.93	0.10	0.21	ND	ND	ND	ND	0.26	0.8	0.63	0.24	0.69	ND	ND	ND	ND	ND	ND	ND	ND	ND	28	24	2	
C003102	5/3/00	San Francisco Waterfront	White Croaker	On	5	25-28	1.79	1.06	1.09	1.12	0.88	3.18	5.10	6.19	0.13	0.23	ND	ND	ND	0.29	0.43	0.8	1.71	0.33	1.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	38	32	2	
C003103	5/3/00	San Francisco Waterfront	White Croaker	On	5	22-27	2.18	2.08	2.08	2.08	1.91	2.87	4.26	6.34	0.14	0.35	0.18	0.24	0.16	0.38	1.01	9.82	0.44	0.94	0.21	0.18	0.15	0.17	0.30	0.22	0.57	0.55	26	2	ND			
C004101	5/24/00	Berkeley	White Croaker	On	5	24-29	2.33	1.32	1.32	1.33	1.13	3.78	5.56	6.68	0.19	0.40	ND	0.21	ND	0.12	0.8	0.34	1.21	0.31	1.13	ND	0.03	0.8	ND	0.03	0.8	0.05	ND	ND	53	37	3	
C004102	5/24/00	Berkeley	White Croaker	On	5	24-28	2.72	1.08	1.09	1.09	0.93	2.42	3.49	4.57	0.14	0.32	ND	0.15	ND	0.08	0.18	1.74	0.32	0.82	0.02	0.8	ND	0.03	0.8	ND	0.03	0.8	ND	ND	61	24	2	
C004103	5/24/00	Berkeley	White Croaker	On	5	25-29	2.95	0.85	0.85	0.85	0.81	2.37	3.80	4.55	0.13	0.29	0.02	0.8	0.15	ND	0.08	0.22	1.38	0.28	0.70	0.03	0.8	ND	0.03	0.8	ND	0.03	0.8	ND	ND	54	23	2
C005101	6/8/00	San Pablo Bay	White Croaker	On	5	23-30	4.93	1.48	1.48	1.48	1.25	4.04	6.35	7.81	0.28	0.43	0.03	0.8	0.21	0.02	0.11	0.22	1.91	0.28	1.06	0.02	0.8	ND	0.03	0.8	ND	0.03	0.8	ND	ND	68	40	4
C005102	6/8/00	San Pablo Bay	White Croaker	On	5	27-30	5.26	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
C005103	6/2/00	San Pablo Bay	White Croaker	On	5	25-30	4.39	2.17	2.17	2.18	1.84	2.84	4.46	6.63	0.21	0.47	0.05	0.8	0.25	ND	0.09	0.8	2.18	8.40	0.39	1.18	0.03	0.8	ND	0.03	0.8	ND	ND	ND	ND	56	28	2
C993A03	9/28/99	S F Waterfront (Muni Pier)	Red Rock Crab	M	20	10-15	NA	0.01	0.05	0.08	0.04	0.08	0.27	0.32	ND	ND	ND	ND	ND	0.12	0.8	0.12	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	18	ND	
C993B03	9/28/99	Fort Baker	Red Rock Crab	M	20	10-13	NA	0.01	0.05	0.09	0.04	0.04	0.24	0.29	ND	ND	ND	ND	ND	0.15	0.8	0.11	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	0.8	ND	
C993C03	9/30/99	S F Waterfront (Pier 7)	Red Rock Crab	M	20	10-13	NA	0.01	0.05	0.09	0.04	0.04	0.25	0.30	ND	ND	ND	ND	ND	0.16	0.8	0.07	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	0.8	ND	
C993D03	9/30/99	Composite	Red Rock Crab	M	80	10-15	NA	10.75	10.93	11.11	10.72	2.55	4.08	15.01	8.85	0.29	ND	12.30	ND	NA	4.64	3.60	NA	NA	0.18	ND	ND	ND	ND	ND	ND	ND	NA	75	25	ND		
Q000021	5/1/00	Duplicate of C001103	White Croaker	On	5	26-30	3.62	1.60	1.62	1.64	1.37	3.78	NR	NA	0.11	0.51	ND	0.32	ND	ND	0.69	2.29	0.37	1.41	ND	ND	ND	ND	ND	ND	ND	ND	ND	78	37	3		
Q000022	8/12/00	Duplicate of C002304	Jacksmelt	WB	15	25-30	2.03	0.07	0.17	0.27	0.15	1.70	NR	NA	ND	ND	ND	ND	ND	ND	1.02	0.70</																

Appendix Table 2f. Selenium concentrations in fish, crab, and clam tissue samples, 1998 - 2000.

Sample ID	Fish ID	Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths cm	% Moisture %	Se µg/g
I005701	82	3/21/00	San Pablo Bay	White Sturgeon	Off	1	115	78.5	1.06
I005702	83	3/22/00	San Pablo Bay	White Sturgeon	Off	1	125	79.5	2.07
I005703	84	3/22/00	San Pablo Bay	White Sturgeon	Off	1	117	80.8	1.33
I005704	85	3/22/00	San Pablo Bay	White Sturgeon	Off	1	149	81.2	1.41
I005705	86	3/23/00	San Pablo Bay	White Sturgeon	Off	1	133	80.7	1.17
I005706	87	3/24/00	San Pablo Bay	White Sturgeon	Off	1	147	77.4	3.22
I001701	22	4/19/00	South Bay Bridges	White Sturgeon	Off	1	182	76.3	1.32
I001702	23	4/19/00	South Bay Bridges	White Sturgeon	Off	1	130	79.9	1.68
I001703	24	4/19/00	South Bay Bridges	White Sturgeon	Off	1	121	78.4	1.16
I001704	25	4/20/00	South Bay Bridges	White Sturgeon	Off	1	149	77.6	1.72
I001705	26	5/18/00	South Bay Bridges	White Sturgeon	Off	1	122	79.3	1.24
I001706	27	5/19/00	South Bay Bridges	White Sturgeon	Off	1	135	78.5	1.42
C993A01		9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	M	10	12.3	82.0	0.75
C993A02		9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	M	10	12.2	80.0	0.89
C993A03		9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	H	20	12.3	83.8	0.99
C993B01		9/29/99	Fort Baker	Red Rock Crab	M	10	11.1	78.3	1.01
C993B02		9/29/99	Fort Baker	Red Rock Crab	M	10	11.3	81.0	0.49
C993B03		9/29/99	Fort Baker	Red Rock Crab	H	20	11.2	79.5	1.23
C993C01		9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	M	10	12.1	78.1	0.84
C993C02		9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	M	10	11.2	76.8	0.78
C993C03		9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	H	20	11.7	72.4	1.45
C981A01		4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	3.7-4.5	87.5	1.27
C982A01		4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	All	25	3.3-4.5	88.0	0.59

Units expressed as wet weight.

Off = Skin-off muscle, M = muscle, H = hepatopancreas, All = all soft tissue

Sample ID and Fish ID are unique identifiers for each individual or composite fish sample

Appendix Table 2g. Concentrations of 11 metals in crab and clam tissue samples, 1998-1999.

Sample ID	Date	Station	Species	Tissue Analyzed	# Homogenized	Average Length	% Moisture	Total Arsenic	Inorganic Arsenic	Aluminum	Chromium	Manganese	Nickel	Copper	Zinc	Silver	Cadmium	Lead	Iron
						cm	%	µg/g		µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
C993A01	9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	M	10	12.3	82.0	3.09	ND	12.4	0.40	0.48	0.23	8.8	40	0.09	0.02	0.014	NA
C993A02	9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	M	10	12.2	80.0	3.34	ND	14.8	0.54	0.50	0.25	8.9	46	0.09	0.02	0.014	NA
C993A03	9/28/99	Municipal Pier (SF Waterfront)	Red Rock Crab	H	20	12.3	83.8	2.56	0.023	2.2	0.18	1.10	0.19	17.0	15	0.19	5.02	0.040	NA
C993B01	9/29/99	Fort Baker	Red Rock Crab	M	10	11.1	78.3	3.18	ND	11.6	0.34	0.55	0.11	11.4	46	0.10	0.01	0.050	NA
C993B02	9/29/99	Fort Baker	Red Rock Crab	M	10	11.3	81.0	2.91	ND	12.2	0.45	0.37	0.19	10.2	36	0.11	0.02	0.038	NA
C993B03	9/29/99	Fort Baker	Red Rock Crab	H	20	11.2	79.5	2.60	0.030	7.2	0.31	1.73	0.40	22.1	20	0.25	7.16	0.055	NA
C993C01	9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	M	10	12.1	78.1	2.88	ND	10.0	0.62	0.64	0.09	8.5	44	0.07	0.03	0.017	NA
C993C02	9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	M	10	11.2	76.8	2.85	ND	12.4	0.63	0.75	0.28	9.9	49	0.07	0.01	0.019	NA
C993C03	9/30/99	Pier 7 (SF Waterfront)	Red Rock Crab	H	20	11.7	72.4	3.22	0.029	12.4	0.52	2.13	0.50	38.3	31	0.36	10.75	0.053	NA
C981A01	4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	NA	87.5	2.17	NA	133	0.68	7.52	1.64	1.5	13	0.36	0.25	0.19	119
C982A01	4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	All	25	NA	88.0	2.31	NA	99	0.85	3.68	1.24	1.8	23	0.13	0.23	0.46	105
MDL			MDL					0.04	0.002	0.05	0.03	0.003	0.006	0.003	0.02	0.01	0.002	0.002	

All units expressed as wet weight MDL = Method detection limit
M = crab muscle, H = crab hepatopancreas, All = clam soft tissue
NA = Not available (not measured)
ND = Analyte below detection limit
Sample ID is a unique identifier for each sample

Appendix Table 2h. PAH concentrations in clam tissue samples, 1998

Sample ID	Date	Station	Species	Tissue Analyzed	# Homogenized	Range of Lengths	% Lipids	Total PAHs	Naphthalene	Biphenyl	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[e]pyrene	Benzo[a]pyrene	Perylene	Indeno[1,2,3-cd]pyrene	Dibenz[a,h]anthracene	Benzo[ghi]perylene
C981A01	4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	All	25	3-7-4-5	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C982A01	4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	All	25	3-4-5	0.9	206	ND	ND	ND	ND	ND	27	ND	83	70	13	13	ND	ND	ND	ND	ND	ND	ND	ND

All PAH values are presented as ng/g wet weight

ND = not detected (detection limit = 10 ng/g)

a not including alkylated PAHs or heterocyclic aromatic hydrocarbons

Alkylated PAHs and Heterocyclic Aromatic Hydrocarbons:

Sample ID	Date	Station	Species	C1-Naphthalenes	C2-Naphthalenes	C3-Naphthalenes	C4-Naphthalenes	2-Methylnaphthalene	1-Methylnaphthalene	2,6-Dimethylnaphthalene	2,3,5-Trimethylnaphthalene	C1-Fluorenes	C2-Fluorenes	C3-Fluorenes	C1-Dibenzothiophenes	C2-Dibenzothiophenes	C3-Dibenzothiophenes	C1-Phenanthrenes/Anthracenes	C2-Phenanthrenes/Anthracenes	C3-Phenanthrenes/Anthracenes	C4-Phenanthrenes/Anthracenes	1-Methylphenanthrene	C1-Fluoranthenes/Pyrenes	C1-Chrysenes	C2-Chrysenes	C3-Chrysenes	C4-Chrysenes
C981A01	4/8/98	Burlingame (South Bay)	Tapes Japonica Clam	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C982A01	4/8/98	Fruitvale Bridge (Oakland)	Tapes Japonica Clam	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	16	12	ND	ND	29	ND	ND	ND	ND

All PAH values are presented as ng/g wet weight

ND = not detected (detection limit = 10 ng/g)